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Title

A retrospective review of educational interventions and innovations using actor network theory. Creating learning designs that develop human capabilities by purposeful assembly of heterogenous actors.

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Abstract

This thesis contributes an approach to learning design for education professionals which can be applied to reform or transform practice through a process of iterative development. The approach can be used by teachers with their class, in a subject area, by a whole institution or system wide, and by researchers as well as curriculum designers. The approach is contextualised, with each potential implementation being different as a result.

The ‘retrospective’ approach taken in this thesis stems from agile product development, where a team looks back over recent practice to see how things were done , how they might be done differently in future iterations and what to stop doing. The retrospective was developed using actor network theory to engender reflexivity over the output time period. I adopt various reflexive positions within the text and interestingly, output 8 was instrumental in catalysing the retrospective in this form. My thesis therefore contributes as a model that others might find useful to analyse their practice.

The thesis uncovers several positional transformations in my own practice. This includes a movement from tracing cause and effect to mapping wider systems giving insight into how networks are bounded, their borders drawn, power relationships established, and notions of absence, presence and othering are manifested. This wider view enabled a discussion of the purpose of education and the realisation that my practice is situated within both a neoliberal and global economy. The later papers consider ways of acting within this environment, by focusing on the capability approach to determine whether education systems either support or limit possibilities

for human flourishing. Focusing on the notion of agency freedom, I connect the capability approach to agile work practices and self-organisation.

The thesis concludes with a proposal that flips actor network theory from being an analysis tool to a potential scaffold for agentic learning design, alongside agile product development and capability approach. The scaffold and contribution to knowledge is formed through six principles that combine actor network theory, agile product development, iterative design, and self-organisation through a reflexive positioning. In this way, a purposed actor network can assemble to develop learning environments that recognise freedoms and constraints, but are closer to emancipatory than transmissive.

Prologue

The prologue provides an overview of the outputs (eight papers written over nine years), and how different themes emerged before the subsequent retrospective analysis using actor network theory (ANT) added different insights (Callon & Latour 1981; Latour 1987; Law 1994). Most of the outputs were written in response to funded project work as part of my commercial and research development role, and they highlight a tension between competing educational objectives. According to Williams (1965), these include the needs of the economy, cultural transmission, and realising the potential of individuals.

The papers cover education interventions and their impact on both human actors — learners, teachers and administrators —and the wider constructs of curricula, pedagogy and assessment. All are concerned with digital technologies, except five and six, which focus on agile work practices (AWP) and resilience programmes. An intervention is defined here as a project that seeks to reform or transform current educational practice in context. This focus on change is rooted in notions of equity and rights-based education (Robeyns 2005) so that individual potential can be realised and capabilities (Sen 1992) developed. Equally, one cannot hide from the needs of the economy or the transmission of culture because these are linked to the realisation of capability. Thus, if current systems, in their educational purpose or ideology, create inequalities, then change is needed and this thesis provides a framework for this.

The interventions span different phases of education, from primary schools to higher education and contexts within the UK, Turkey and Palestine. The retrospective

analysis broadly considers the areas of curricula, pedagogy and assessment through the different foci of each paper. The purpose of education within a neoliberal global economy is considered alongside how possible responses, invoked by neoliberalism, might lead to transformation through the capability approach (CA) (Sen 1992). In addition, aspects of self-organisation (Brandt 2016), human agency (Bandura 2001), agile product development (APD) (Takeuchi & Nonaka 1986) and concepts of technology are explored.

Outputs 1–4 start from a belief that acknowledging the digital habits of learners and the use of digital technology is sufficient to develop personalised and collaborative education. However, outputs one and two in fact highlight pedagogy. This theme is developed in outputs 5–8, which consider changes to pedagogy and the development of agency and human capability. In the earlier outputs, I was interested in the socio-technical alignment of interventions but had a technological determinist standpoint in believing that digital technology is transformative in itself. This view is still partly evident in the field of educational technology, as digital technology is employed to enhance the current educational system, often to little effect. ANT argues against this binary reductionism (focusing on one actor over another, for example, technology over pedagogy), noting that there is no separation between material things and humans, and that one does not drive the other by combining them in heterogenous networks to effect change (Law 1992). Because I was unaware of ANT at the time, I thought it was simply a case of making an input ‘a’ to change points ‘b’ and ‘c’. This was probably my contemporary ‘ed tech’ viewpoint, that if only people would adopt technology, all would be fine. This view quickly switched to a standpoint of ‘there is no agency in technology’ (output 1), and I started

to consider how changes in pedagogy might accommodate the digital habits learners developed outside their educational contexts (outputs 2–4). I believed that these habits could be recruited for learning purposes based on the match or fit of learners' abilities with the requirements of curricula, pedagogy and assessment. I also started to think about the role and identity of the teacher as a curator and facilitator of knowledge/learning (outputs 2, 5, 7–8) with the advent of the cloud and especially after seeing Michael Wesch's 'A Vision of Students Today' viral video (2008) on how digital technology is seen as an escape from the classroom as much as a connection to wider knowledge from external sources. I realised that there were wider networks of locations for learning and that knowledge and skills are not only vested in an individual, and the notional, if not physical, movement of content and attention from and to the learning space.

Most of the interventions were oriented towards ensuring equitable access to education and expanding learner capabilities, as notions rooted in my experience of teaching and learning before I entered the academy. The CA started to feature in paper three after I used it in another funded project (Young Dads' TV evaluation 2013). The young (single) dads' experiences were broadly about becoming visible and engaging with society directly in a world that seemed skewed towards mothers. The CA, and the work of Burchardt and Vizard (2009) on an equalities framework, was a different approach to assessing whether the young dads were able to achieve a life they valued. I realised that the CA could apply to educational interventions, although much of the literature at the time was concerned with adult rather than children's capabilities. I also started to examine the idea of agency in education practices where teacher-centred, often didactic methods were used. I realised how

different pedagogic approaches that engaged learners directly in controlling their own learning could reconfigure agency. Output four focused on the ‘match or fit’ between learners’ digital habits and the way they might be taught. I thought that integrating digital competencies and skills might develop participation and improve outcomes. This mindset was rooted in a belief that education is a social good that should be accessible to all, whatever their needs. By the time of writing output four, I had yet to realise the view that education provides human capital within the global neoliberal economy (Hayek, 1944). Although I was thinking about rights and capability, I still thought that the purpose of education was to enhance people’s skills and knowledge so that they could participate in the economy. I possessed what Fenwick and Edwards (2012, p.9) called a developmental outlook or ‘developmentalism which dominates the pedagogical gaze, positioning learners in continual deficit and learning activities as preparation for some imagined ideal.’

Output five considered pedagogy as a technology and recruited APD (Takeuchi & Nonaka 1986), partly based on integrating the concept of self-organising, collaborative teams into education. This was justified as a potential pedagogy that would afford greater learner agency and choice in how to learn, alongside bringing in ‘current’ work practices. I then realised that changing pedagogy alone would be ineffective or unsustainable, and advocated that assessment should change in order to drive changes to pedagogy and curricula. I realised that these three factors are connected, but had not considered them holistically as elements within a wider system.

Output six looked at capability and rights as a way of evaluating educational interventions. The concept of therapeutic governance (Pupavac 2001; Nolan 1998; Ecclestone & Lewis 2013) allowed a different perspective on education and the economy and how they are configured. The notion of how certain approaches to education are constructed and maintained was an aspect of output seven, which looked at how existing approaches might be changed through different pedagogies that "act back" to influence the wider education system. Now, I think that because output seven was located in Palestine, the presence and influence of the occupation made me more aware of the potential power dynamics at play, and how that impacted on individuals and the education system. As my interest in how pedagogical approaches might construct agency, identity and change grew, I also started to look at self-organisation (SO) (Brandt 2016; Ward 1966) and the different ways in which collaboration and 'agency freedom' as part of the CA could be realised (Sen 1992; Robeyns 2005; Nussbaum 2011) (agency freedom refers to the freedom people have to choose actions or possibilities that may lead to a life they value). Alongside this, I also discovered ANT, giving insight into how educational interventions can be analysed holistically, and laying to rest the human-socio-technical divide in my thinking. In 2019, I took two Agile courses involving systems thinking, organisational change, and self-organisation, and realised that these methods could be applied to educational systems and transformation. As a result, I made links between design-based thinking, co-construction, and SO. I also attended several seminars on the purpose of the economy, sustainability, and renewable resources. After a discussion with a colleague, I read Heidegger's *Question Concerning Technology* (1977). This led me to reconsider the purpose of technology, and how education is part of a global economy predicated on continued growth and

the exploitation of natural resources, rather than looking at more sustainable regenerative economies (Fullerton 2015).

It is significant that education is positioned as an integral part of the neoliberal and global economy, rather than as a progressive force for human development. Such positioning is based on notions of competition over collaboration, and exploitation of natural resources over sustainability. Olsen and Peters (2005) link neoliberalism as an economic discourse to the phenomena of globalisation, effected by developments in science, technology, communications and travel; they recognise that 'neoliberalism is a particular element of globalization in that it constitutes the form through which domestic and global economic relations are structured' (Olsen & Peters 2005,p.312). Monahan (2004, p.274) notes how globalisation 'penetrates into public education through the combination of certain rationalities, both neoliberal (e.g., privatization, vouchers, flexible and docile students) and neo-conservative (e.g., standards, accountability and traditional values).' Whilst ANT can be used to analyse the purpose(s) of educational interventions and their networks through the process of problematisation (Callon, 2004) such interventions remain part of the wider global, neoliberal economy .

As a consequence, it is important to pay attention to both the 'purpose' of each intervention from the perspective of the originator and the wider educational purpose it might serve. Fenwick and Edwards (2012, p.9) note that ANT analysis encourages educators to 'step outside of the "enculturation" project that typifies pedagogies ranging from the emancipatory to the transmissive.' In this regard, outputs seven and eight are concerned with participative approaches to education and the effects that

these might have on transforming curricula, pedagogy and assessment in their situated context. As such, they explore what happened rather than favouring one particular approach over others, although perhaps they do not quite escape enculturation, save through ANT's insistence that there can be no 'future potential' (Fenwick & Edwards 2012). By this, the authors mean that each actor network (AN) is a singular occurrence, that may not transfer similarly elsewhere. Equally, networks in ANT are dynamic and may fall apart as well as maintain cohesion, and as such are likely to have outcomes that are unpredictable (Latour 1996).

The introduction below charts the emergence of my ontological position and I have attempted to recognise this reflexively throughout. I believe my position is a little idealist in that epistemologically I have an interpretivist/social constructionist approach to my thinking. This has been modified somewhat by how the notion of 'othering' demonstrates that by deciding to include one thing, we may exclude others (Derrida 1976; Law 2004). In a realist commercial sense, i.e. the pressure to finish a project, setting the parameters of an intervention requires a series of decisions; however, it is equally important to realise that choices made may knowingly or unknowingly exclude others.

Selected Outputs

I am submitting this thesis as part of my PhD by published works (listed chronologically) (Appendix 2, separate document). I have selected single and jointly authored outputs which reflect my progression as an author over the time period. The single authored papers amount to 26000 words whilst the joint papers total some 31,000 words. Of the latter a fair estimation of my contribution would be circa

15,000 words. This equates to a total of approximately 41,000 words in previously published works and, along with the commentary of 48,000, ensures equivalence with a PhD by research.

My contribution to jointly authored work is confirmed in Appendix I (a separate document). On outputs 1, 2 and 5 I was the main author and outputs 3 and 4 were more collaborative endeavours. All outputs are peer-reviewed journal articles. In the text, I mostly use 'I' to refer to my authorship but occasionally use we when referring to joint efforts.

Output 1. Royle, K. Jenkins, C. Nickless, J. (2010) 'Combining analogue realities and digital truths: Teaching kids how to hold productive learning conversations using PictoChat on the Nintendo DS,' *RJET* Ohio: Kent State University Press,6,(1)pp.76-93. (7,000) words.

Output 2. Royle, K. & Hadfield, M. (2012) 'From 'Posh Pen and Pad' to participatory pedagogies: One story of a netbook implementation project with 108 Pupils in Two Primary Schools,' *International Journal of Mobile and Blended Learning*, 4(1), pp.1-17.

Words (7100)

Output 3. Royle, K., Stager, S. and Traxler, J. (2014) 'Teacher development with mobiles: Comparative critical factors,' *Prospects*, 44(1), pp.29-42. doi:10.1007/s11125-013-9292-8. Words (5500)

Output 4. Keskin, N. O. Royle, K. (2015) ‘Examining digital literacy competences and learning habits of open and distance learners,’ *Contemporary Educational Technology*, 6(1), pp.74-90. Words (5469)

Output 5. Royle, K. and Nikolic, J. (2016) ‘A modern mixture, agency, capability, technology and 'Scrum': Agile work practices for learning and teaching in school,’ *Journal of Education & Social Policy*, 3(3), pp.37-47. Words (6389)

Output 6. Royle, K. (2017) ‘Resilience programmes and their place in education: A critical review with reference to interventions in Wolverhampton,’ *Journal of Education and Human Development,* 6(1), pp.1-8 Words (8700)

Output 7. Royle, K. (2019) ‘Opening spaces for the development of human agency with problem based learning in Palestinian higher education,’ In: Uden L., Liberona D., Sanchez G., Rodríguez-González S. (eds) *Learning Technology for Education Challenges*. LTEC 2019. *Communications in Computer and Information Science*, 1011, pp. 260 - 278. Springer, Cham. Words (7700)

Output 8. Royle, K. (2020) ‘What’s good what’s bad? Conceptualising teaching and learning methods as technologies using actor network theory in the context of Palestinian higher education,’ *Postdigital Science and Education* (2020). https://doi.org/10.1007/s42438-020-00138-z Words (9500)

Introduction

And you may find yourself

Living in a shotgun shack

And you may find yourself

In another part of the world

And you may find yourself

Behind the wheel of a large automobile

And you may find yourself in a beautiful house

With a beautiful wife

And you may ask yourself, well

How did I get here?

Byrne et al. (1981)

This section explains the development of my positioning on education and how my underlying philosophy emerged to focus on rights-based, participant-directed processes and other learner-centred methods responsive to authentic contextual issues. The retrospective approach is metacognitive in that it increases my awareness of motivation and thinking, contextualises the diversity of the subject of my writing whilst in the academy, and identifies the themes that run more deeply through the selected outputs. It also examines the events and professional practice that formed the outputs, for example, why I made certain choices and chose particular approaches. Reflection is part of teaching (Schon 1983; Dewey 2009) and an ‘epistemology of practice’ (Schon 1983), and so it is appropriate to employ it here to steer a course and examine how I got here. As Dewey notes, ‘reflective thought is

the active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it' (Dewey 1909, p.6).

ANT is a central tool of the retrospective, and, as Callon (1984) suggested, actor networks are always assembled for a purpose or goal in 'assemblages of the social' (Latour 2005) which can be comprised of human and non-human actors (heterogenous networks (Law 1992)). Human actors are not privileged over non-human actors, in what Latour (1987) calls symmetry or symmetrical analysis. In using ANT for retrospective analysis, I contemporaneously become an actor in each output's network, but am also the writer of the retrospective analysis. From this latter position, I have sometimes added actors (as part of the retrospective construct) who were previously not considered in the outputs. By recognising their presence and assigning purposes in drawing the network, I endeavour to make this positionality clear in the text. Being able to take this second look elevates the ideal over the reality at the time, and sometimes I may seem to be judging earlier outputs a little harshly. For example, in output one, the students are taken for granted in the research and so they have been added, and likewise the Nintendo DS is attributed more agency within the project than was then represented. I realise, however, that this stems from my retrospective position and is an addition and interpretation. I would emphasise here that constructing a retrospective invites reflexivity as much as reflection, as it invites contemplation about the why of my past practice through an emerging positionality constructed through the text, rather than an attempt to reconstruct and modify the past.

Indeed, as Latour (1990) notes,

> reflexivity is not a “problem”, a stumbling block along the path to knowledge, the prison in which all enterprises would be locked, it is the land of opportunity at last opened for actors which are primum inter pares, or strive for parity or primacy like any other (p.14).

Those researching or conducting analysis through ANT need to consider themselves as part of the ‘assemblage’, and thus are not privileged above other actors but are cognisant of place and action. This has two implications. One is that I was an actor at the time, and the other is I am now also a reviewer engaged in retrospectively drawing the networks from the texts. ‘Assemblage’, according to Law (2004), was translated from the French ‘agencement’, which means to arrange, combine and order; as such, an assemblage is a combination of things for a purpose and therefore agentic. Similarly, Watson, Verran and Turnbull (1995, p.117) state that ‘It also has the virtue of connoting active and evolving practices rather than a passive and static structure.’ Fenwick and Edwards (2012, p.9) also warn against privileging the researcher’s position, ‘ Familiar issues of reflexivity are no less problematic in ANT accounts, which can objectify networks as something produced solely in the eye of the researcher’ and, although this is somewhat inevitable, I have attempted to make the reader aware of my position by reflexively recognising the choices I made in creating the actor networks anew in each paper. Law adds that:

> reflexivity may be seen as an extension of the principle of symmetry: in effect it says, there is no reason to suppose that we are different from those who we study. We too are products. If we make pools of sense or order, then these too

> are local and recursive effects, and have nothing to do with immaculate conception, or any other form of privilege (1994, p.16).

Law posits that the researcher is part of the contemporaneous network but also enters a further account. Consequently, I note four positions that act: myself as an actor (researcher) within the network at the time; the retrospective that reviews and constructs anew what was missed, or now seems misunderstood; myself as an actor within this new construction; and, finally, my reflexive self and owner of the present narrative which attempts to interpret and analyse these positions.

The following sections trace particular influences, orientations and experience from my work and education and link them to themes within the outputs. Herein the origins of educational purpose, agency, self-organisation, neoliberalism, capability, technology, collaborative practice, authenticity and agility are discovered.

Thinking about the origins of my thinking

Hayfield is a small village in the High Peak in Derbyshire in the shadow of Kinder Scout. I went to school there in the late 1970s and in the neighbouring town of New Mills. Hayfield was a Pennine mill village specialising in paper production and calico printing, transitioning through industrialisation to become a commuter village for Manchester 30–45 minutes away. To visit Hayfield now, you would think it a rural idyll, but in the 1970s and early 1980s it was on the urban fringe and in post-industrial decline. As the mills closed, the options for future work also reduced. Of my class at Hayfield Primary School, I was alone in eventually studying A levels, and

for the others there was a limited choice either in education or work. This may partly have been a legacy of the Butler Education Act (1944) and the post-war settlement which introduced grammar, technical and secondary modern schools. Even though the original plans prepared by Norwood (1943) were quite egalitarian and included compulsory education until 18, parity of school amenities and selection based on teachers' judgement and parental wishes, in reality who went where, was decided by the 11+ exam. This ostensibly sorted people by ability into professional/academic, skilled, and semi/unskilled. This was an indication that schooling was still aligned to the needs of industry and yet, in reality, few technical schools were ever built (PSC 2016). Young people judged to be 'academic' (in England and Wales) went to grammar schools and everyone else went to the secondary modern. By the time I attended secondary school, the comprehensive system was replacing or combining the two types of school, at least in some parts of the UK. It has long been argued (Bourdieu 1974; Foucault 1975; Bernstein 1975) that schools are a key social classifier and, reflecting on my experience as a pupil, this would appear to be true.

Robeyns (2006, p.13) distinguishes three normative accounts of education policies: human capital, rights, and capabilities, noting that, 'the human capital model only stresses the instrumental economic roles of education. The right to education model mainly highlights the intrinsic personal role of education. The CA acknowledges all roles of education'. My initial approach to education as a teacher was grounded in creating equity of access, as in the human capital model in Robeyn's classification. Alongside this, I also believed that education was a right and I had no more nuanced way of situating my practice. Bourdieu's challenge to 'the optimistic liberal perception of the school as an instrument of social reform and equality' (Nash 1990, p.431) had

not invaded my consciousness. At the time and subsequently, I accepted the notion of education as a 'force for good in society' and it was only recently in Ramallah after a conversation about education with a Palestinian colleague, who said "you cannot understand Palestine without understanding Foucault — we create our own constraints", that I had a kind of quasi-damascene conversion. I discovered that she was talking about understanding education as a type of surveillance, socialisation, and control, as in Foucault's *Discipline and Punish* (1975). I investigated this notion further in output seven, as I was interested in the idea of 'agency'. It follows that even the notion of planned agency may be part of our own oppression. As Foucault notes, schooling:

> distributes pupils according to their aptitudes and their conduct, that is, according to the use that could be made of them when they left the school and that it classifies them towards the same model, so that they might all be subjected to subordination, docility, attention in studies and exercises, and to the correct practice of duties and all the parts of discipline. So that they might all be like one another (Foucault 1975, p.182).

This assertion is recognisable in education institutions today and certainly resonates with my own experience of school. For educators with such insight, this could quite easily invoke feelings of hopelessness, depending upon what the educator does with their knowledge. Fortunately, some authors (Leask 2012; Thomas 2008; Postma 2015) have posited the idea that Foucault could be inviting 'critical agency', where 'the subjects, may not be able to get outside power, but the incompleteness of power's domination often gives us ways of involving ourselves in powerful transformations' (Thomas 2008 p.156). Bourdieu notes that education 'is in fact one

of the most effective means of perpetuating the existing social pattern, as it both provides an apparent justification for social inequalities and gives recognition to the cultural heritage' (Bourdieu 1974, p.32). Under this premise, schools are predominantly designed for those in the dominant culture, to the detriment of other classes. Educational achievement has become part of a self-perpetuating 'meritocracy' biased in favour of the dominant groups, who learn how to engage with school culture through its alignment with the culture in their homes. My earlier outputs (1–4) attempted to provide access to an education system that ultimately reproduces inequalities. Here, I reflect that actors within the system, teachers, leaders, researchers and decisionmakers consistently attempt to make improvements, striving to effect change despite sometimes not recognising the inherent unfairness in the system itself. Indeed, Nash (1990) suggests that one failing of schooling is 'its structured refusal to develop a "universal pedagogy" —a pedagogy that takes nothing for granted —able to succeed with relatively unprepared working class pupils' (p.436).

Outputs 7–8 recognise that 'rights-based' 'access to opportunities' through the development of the human capital approach will be less achievable without major change in the purposes of education. This realisation was a fundamental shift for me because, despite years spent facilitating access to learning and ultimately employment for learners, I realised that the education system itself may often be obstructive. In the mid-1970s, contrary to the Newsom Report's (1963) recommendation that 'excessive use of ability grouping should be avoided', my own secondary school streamed students, in order to realise seemingly pre-determined outcomes and subsequently providing evidence for an 'aptitude to school' based distribution. Such streaming is also similar to grouping and setting (*see*, Boaler et al.

2002). The school used the word SPECTRUM, whereby S, P and E were the ‘academic’ forms and the others were more aligned with the skilled, semi-skilled and unskilled requirements of the labour market. The social construct of education, despite the so called ‘progressive’ agenda of the 1960–70s (*see*, Barrs & Rustin (2018) for a fuller discussion of the ‘Black Papers’ and the ‘invention of progressivism’), still seemed to be stuck in 1944. As a result, my friends from primary school became skilled engineers or tradespeople, and machine/general operatives at either Ferodo brake linings or Swizzels sweet factory, or joined the armed forces. Bourdieu and Passeron (1990) argue that this delineation is part of a school’s purpose and that different classes exclude themselves from accessing the dominant culture by ‘eliminating themselves’, either by choosing other paths or not aspiring to academic examinations; more than this, however, such outcomes are within the school’s design:

> It [school] contributes irreplaceably towards perpetuating the structure of class relations and, simultaneously, legitimating it, by concealing the fact that the scholastic hierarchies it produces reproduce social hierarchies.[…] doubtless the best concealed of all the functions of the School (Bourdieu & Passeron 1990, p.205).

Ferodo used asbestos in its products until 1998 and Swizzels, famous for Love Hearts and Refreshers, was a minimum wage employer. Two friends who joined the armed forces were involved in the UK’s final colonial wars in the Falklands and Northern Ireland. Reflecting on this, it all seemed a little inevitable and predetermined and, when I became a teacher in 1985, I was driven to address what I saw as structural inequalities in how education treats learners.

Becoming an educator in a time of neoliberalism

In 1981 I started a BA in history and historiography, including African history, war and society. It was taught in a liberal arts tradition and there was still little notion of studying for employability. When I graduated in 1984 the miners' strike was in full swing and the unemployment rate had been over 11% for three years. This coincided with the policy enactment of a neoliberal (Hayek 1944; Friedman 1965) competitive, market-driven project under the first Thatcher government (1979), and ultimately led to the increased marketisation of education. This neoliberal restructuring of schools in England and Wales preceded Thatcher, according to Barrs and Rustin (2018). They argue that it had been an ongoing polemic since the late 1960s (the Black Papers), but was initiated by the 1976 Callaghan Labour government which noted a 'lack of basic skills' and aligned itself with industry, instigating his 'great debate on education'. As Callaghan stated at the time, 'You [teachers] must satisfy the parents and industry that what you are doing meets their requirements and the needs of our children. For if the public is not convinced then the profession will be laying up trouble for itself in the future' (Callaghan 1976). Olsen and Peters (2005, p.314) defined neoliberalism as 'a politically imposed discourse' in which market rules exercise control through performance regulation and standards in the public sector. In this way, the state becomes increasingly entwined with education and driven by both outcomes and standards, to align education with economic and national needs (Callaghan 1976). Indeed, according to Ball (2013, p.83), the then Labour Secretary of State, Shirley Williams, asserted that the problems of education lay with 'poor teachers, weak head-teachers and head-mistresses and modern teaching methods'. This perception of a 'failing' education system could be seen as a response to the perceived importance of aligning more

directly with the needs of an economy in transition. As I completed my degree, education in the compulsory sector was moving away from being a professionally-controlled endeavour towards a managed service with more centralised control (Ball 2013). Callaghan's 1976 speech, according to Lowe (2004), was pivotal to this change and certainly the long-held view that aspects of society, such as class structures and inequality, were an influence on learner outcomes had started to be debunked by the right (Barrs & Rustin 2018).

As a result of the change in political and economic direction towards a neoliberal stance, my practice in retrospect seems to have been a little schizophrenic. On the one hand, (post-university) I was a product of the liberal arts tradition and rights-based emancipatory education and, on the other, in practice, I have often embraced the managerialism and seeming pragmatism of Thatcher's neoliberal project. Achievement through action plans, relentless productivity, and having the future mapped in increments was very attractive for a while. This is an approach which, on reflection, aligns with what Deleuze and Guattari (1987) term the 'arboreal', where roots and paths are followed in a logical pattern from point to point (tracing) rather than the rhizomic, where anything can be connected to anything heterogeneously (mapping). To an extent, as revealed by ANT, the retrospective charts my path towards using a wider view based on heterogeneity and a movement from the acceptance of existing tracings to the creation of new ones from a wider mapping of purposed systems.

My papers slowly develop a change in attitude and positioning, for example, where outputs 1–2 are basically about projects of inclusion and acquisition of human capital, output three questions the 'purposes of education' against the backdrop of globalisation and notions of developing human capital. Output three notes the following purposes of education: as a preparation for life and work; as a way of socialisation and 'creating better people' (more productive); as a way of bringing marginalised peoples into society; and 'domesticating' nomadic groups. All these conceptualisations are both problematic and justifiable when contextualised against the dominant model of globalisation and knowledge capitalism, which, Olsen and Peters (2005, p.330) argue, denies modification, negotiation or localisation by traditional cultures and values. The same output recognises the imposition of a western-centric view on other locales and, as such, reacts against the dominant discourse:

> Some theorists see education as being a preparation for life and for work; in practice, however, the nature of that education has been distorted by the implicit assumptions these theorists make about the lives and work that different classes and communities are being prepared for. (Output 3, p.4).

The assumptions educators make about educational purpose, possibly framed by the perceived limitations of neoliberal discourse, are difficult to challenge and this is why frameworks such as ANT and the CA enable insightful retrospection and analysis. My use of and attraction to the CA (Sen 1992; Robeyns 2005; Nussbaum 2011) (outputs 3, 5–7) probably stems from the structural inequalities in the economic system which I also now recognise in the education system. The CA is a way of thinking about how we are able or otherwise (due to particular contexts or

systems) to achieve a life that we value. Sen (1992) outlines the major constituents of the CA as functionings and capabilities, where, ‘a functioning is an achievement, whereas a capability is the ability to achieve’ (Sen 1987, p.36, in Zheng 2011). Central to this is ‘agency freedom’ (AF) which is related to freedom of choice and restrictions on choice. According to Robeyns (2006), the CA undermines the assumptions of a neoliberal approach to human capital through the concept of AF, in that ‘A good and just society should expand people’s capabilities but should refrain from pushing them into particular functionings’(2006, p.12).

The outputs rail against a ‘standardised way of doing things’ and while in this sense each ‘acts back’ against what I now see as a neoliberal agenda manifest within those standards, they also act within its parameters. Several of the outputs use the ‘disruptive’ element of digital technology as a catalyst for ‘acting back’ against the ‘system’. This was certainly the intention in output three, which looked at the agency of ubiquitous mobile devices portrayed as a counter to an industrialised system of education (Output 3, p4).

In my development through the outputs, I increasingly step out of my position within the system and look more widely at the elements that comprise it. For example, Bernstein (1975) argues that curricula, pedagogy and evaluation (assessment) are the common message systems of schools that serve the dominant cultural group:

> Curriculum defines what counts as a valid knowledge, pedagogy defines what counts as a valid transmission of knowledge, and evaluation defines what counts as a valid realization of this knowledge (Bernstein 1975, p.85, in Cause, 2010, p.5).

Currently, neoliberalism is arguably the dominant culture not only in western democracies but also within its organisations that support educational development, such as the International Monetary Fund (IMF) and World Bank (George 1999). It is expected that neoliberalism is manifest, not only in Bernstein's three message systems, but also in widely held assumptions about the purpose of education, both in government and educational organisations (Ball, 2013; Barrs & Rustin 2018).

In retrospect, all of the outputs have sought to change, transform or disrupt existing curricula, pedagogy and assessment, generally with more authentic, student-centred approaches. The main issue in retrospect here is that, in my teaching, I carried the 'acting back' nature of my higher education into the pragmatism of the Thatcher era, without realising the wider implications of neoliberalism, which, as Shamir (2008, p.3) notes, is pervasive and hard to recognise overtly having 'penetration in almost every single aspect of our lives'. The outputs, as stated, are located in a core belief in education being a public good and a human right (UNESCO 2018) and this account now appears as both an unravelling and reaffirmation of that belief, written within the increasing extremity and pervasiveness of neoliberalism and state interventions on behalf of the market (Barrs and Rustin 2018) in education.

Recognising unheard voices

The student body in the early 1980s was politicised by collective action in support of both the miners' strike and the anti-apartheid movement. My tutors were an eclectic mix of Communist Party members, ex-colonial service district officers and Africanists who enjoyed the academic freedom of a free, non-performative, higher education

institution. On my course, they used African literature to debunk colonial myths and personal histories to show that the everyday was just as important as the stories of the great and the ‘good’. Being both counter-cultural and counter-factual, this led me to question long-held beliefs and the positionality of my class and upbringing. The outputs reflect this counter-factual positioning, in that the interventions sought to do things differently, mostly against the incumbent orthodoxy. For example, output one is concerned with computer games consoles in the classroom, output three with mobile phones (still banned in many schools) and output five with using a workplace counter-culture in education. Being counter (acting back) and doing something different with selections from the culture seems to be an enduring theme. In forming this attitude, I can see an engagement with historiography and how we use the past to represent our concerns about the present (Carr 1961). This was also connected to whose history was being voiced. The African history course used literature —Ngugi and Achebe —to illustrate colonisation in Africa. On the wall of one of the seminar rooms was a text, now attributed to Achebe, which reads: ‘There is that great proverb —that until the lions have their own historians, the history of the hunt will always glorify the hunter [… As a historian, it] is something we have to do, so that the story of the hunt will also reflect the agony, the travail, the bravery, even, of the lions’ (Achebe 1993).

At the time of writing the outputs, I had forgotten both this stance and my first university essay which asked me to recount my family history. I realise through this retrospective that perhaps this is the reason for my passion for agency , hearing other voices and meaning-making.

My undergraduate dissertation focused on the 1932 Mass Trespass on Kinder Scout (the moorland above Hayfield) (Royle 1984). 1932 was (like the 1980s) a time of high unemployment (22% yearly average in 1932) and binary politics. I interviewed Benny Rothman, who led the Trespass, and visited the Working Class Movement Library (WCML), then a terraced house in Stretford. I read *The Road to Spain: Anti-Fascists at War 1936–39* (Corkhill & Rawnsley 1981), which documented the lives of the working class men and women who went to fight (*see*, Self-Organisation below). This was a counter to Hemingway and Orwell, realising that ordinary voices are often not heard and that places like the WCML existed to document them and make them count. This notion of 'voice' and search for authenticity is also present in the outputs. Output two, for example, develops the argument for a change in teacher identities, whereas output four seeks to incorporate learners' digital habits into the education process. Most of the outputs attempt to bring something into the educational process that is unconsidered or ignored and yet, as the analysis of output one shows, the 'voice' of the students in the research project is often 'othered' (Law 2003). However, this was perhaps a consequence of an emerging understanding of my position as a researcher which developed through the outputs.

Self-organisation and self-management

A key aspect in retrospect is the concept of self-organisation (SO) and my project on the Trespass was significant because it added a layer of understanding about SO, 'acting back' and protest which is reflected in the outputs. However, it was my later project work using Scrum APD that cemented this aspect (output 5). Agility is defined as 'the ability to create and respond to change. It is a way of dealing with, and ultimately succeeding in, an uncertain and turbulent environment' (Agile Alliance

2020). I realised that AWP were related to learner-centred education, as agile practitioners facilitate the development of self-organising teams and conditions that release collective and individual agency . SO is central to the Scrum APD framework (the foremost Agile framework) for software development, (Sutherland & Schwaber 1995). My interest in AWP (output 5) and Problem-Based Learning (PBL) (outputs 1–2 and 7–8) focus on developing self-managing student teams within teaching and learning, and how SO is connected to agency (freedom) and capability. There is a nuanced distinction between self-organising teams and self-management (SM). The latter applies the motivation of SO within an existing organisational structure, to enhance the productivity of the organisation or team. The purpose for action within SM is normally externally set and only how a goal is achieved is left to a self-organising team. The more agency a group has, the more control it will have over the purpose for self-organising and is predominantly a structure for single projects rather than a repeating pattern of behaviour.

Looking back at SO within the Trespass intrigued me. I had experienced (aged 21) the power of the state as the miners' strike was smashed in the Derbyshire coalfields, and yet the Trespass (1932) had challenged this power. A group of young factory workers (of similar age to myself) had self-organised to protest their right to walk on private land, in purposeful defiance of the status quo. This event in retrospect initiated my interest in the mechanisms of SO and the agency, control, planning and determination that could occur as a result (Pendleton-Jullian & Brown 2018). Outputs 7–8 examine the components of SO in more detail within PBL, where teachers pass control to learners, who are expected to work out solutions for themselves collaboratively. Output seven investigates changes brought about

through PBL and output eight follows on by looking at the dynamics of the mechanism of agentic action behind PBL, using ANT. SO is also present in outputs 1–2, and seems pervasive in any situation where control is transferred through a degree of learner self-direction (Graaf & Kolmos 2003). According to Brandt (2016), SO requires three elements: a purpose or goal, a set of rules or principles, and an element of tension or an imperative. These elements (Fig. 1) can be applied retrospectively to the outputs to see if they were present in the interventions.

Figure 1. The triangle of self-organisation (source: Brandt 2016)

Brandt's ideas (2016) echo the drivers of SO used in forms of industrial organisation. Ward (1966), Laloux (2014) and others have documented SO and SM in more depth and each of its three elements can be multi-layered. Indeed, Brandt's elements can be seen in the Trespass, in which the goal was to gain access to privately owned (previously common land enclosed by the acts of enclosure 1750-1850) moorland for mass recreation: 'It was a sense of freedom; the wind was blowing: the rain was lashing onto you. We went to get out in the open, away from the town conditions' (Royle 1984). Many of the outputs share this story of agency and control, rights and

common goods versus control by forms of capital. SO's importance is in the release of agency that can lead to the development of capabilities (output 8). Benny Rothman and the British Worker's Sports Federation's (BWSF) campaign was a matter of agency and choice about how and where one walked (access to 'common' land)– it was a rights issue made manifest through the SO of a concerned group. Capability and AF are also central, where the capability (to walk outdoors) and desired functioning (walking on the moors) was being denied. The trespasser's purpose for SO, was arguably part moral (rights-based) and part political (acting back/ anti-capital) whilst the rules/principles were inherently political, (the BWSF was affiliated to the Communist Party). This gave them a supportive framework and counter-narrative within which to act. Rothman and many of the trespassers were politically conscious in the context of the time: 'Dozens of those who fought landowners on that mass trespass were later to fight and die in Spain (in the Civil War)' (Thomas 2014, p.21). In Brandt's model, the imperative was the denial of rights that forced the group to act. As Rothman put it in 1983, 'We took a group onto Bleaklow and were turned back. So we decided to organise a mass trespass to prove our point' (Royle 1984).

In education, SO is more likely to be realised through SM, where an organisation grants some control to learners. Hackman's conceptualisation (1995) (Fig 2.) shows approaches to team management and the distribution of control, which can be used in education to determine how different pedagogic approaches develop learner agency.

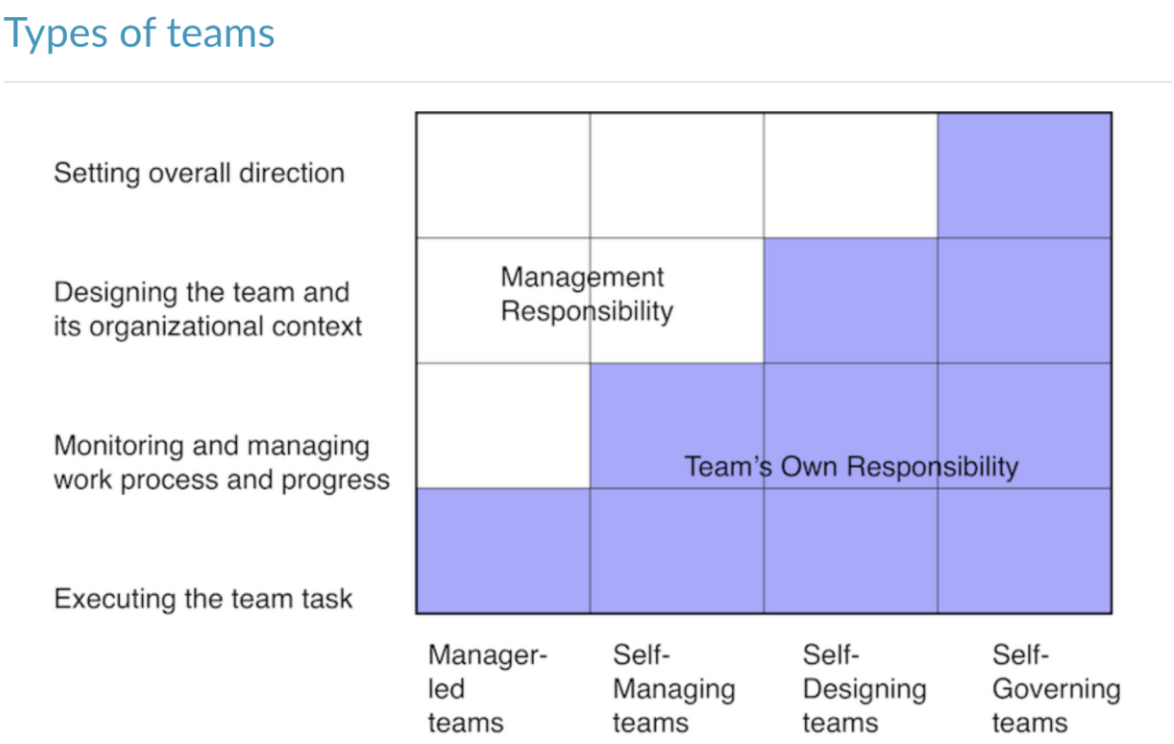

Figure 2. Types of team. Adapted from Hackman (1995). Diagram attributed to https://less.works/less/management/self-managing-teams.html

AWP are derived from the Toyota Production System (TPS) Ohno (1982, 2009) and Takeuchi and Nonaka's paper (1986), which led to the development of Scrum by Schwaber and Sutherland in 1995. The TPS (Fig. 3) moves control away from management towards self-organising teams; it maintains elements of managerialism but allows workers to control quality, and innovate and inspect production processes to improve practice. Although TPS workers have no choice (AF) but to develop the management's product vision, they do have SM systems within this structure. This is different to traditional organisation (TO) structures that focus on product volume and manage workers directly. TO command and control structures (inverted in the TPS) is arguably replicated in education, where students follow a prescribed process of

learning directed by teacher-centred pedagogy, with little personal agency or responsibility for quality.

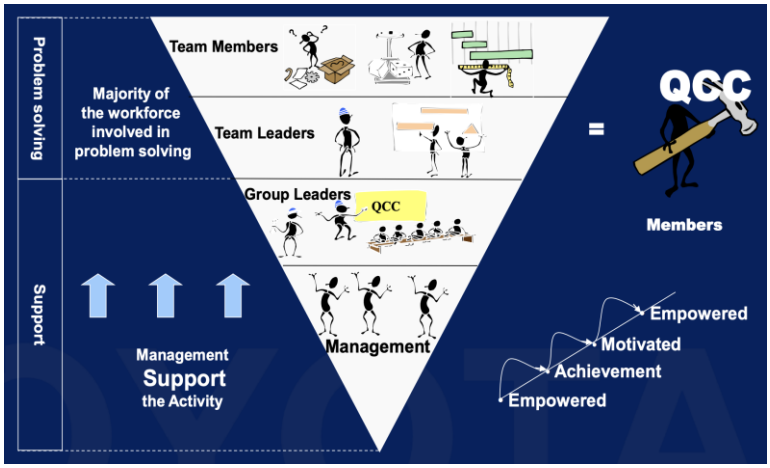

Figure 3. The TPS solution to command and control, where workers solve problems and improve quality, and management facilitate the process (Source: McArdle 2020)
QCC = quality control circles

Both SO and SM have earlier roots than the TPS and Scrum. Self-governing SM was a key strategy for the anarcho-syndicalism movement in Spain during the civil war, when industry and agriculture were collectivised and democratised under worker control. In this regard, Dolgoff stated that, 'the movement was decentralized, to allow for the greatest degree of initiative and decision-making at the base, and to provide structural guarantees against […] bureaucracy' (1973, p.xxii). Equally, Ward notes that anarchist organisations should be: voluntary, functional, temporary, and small; besides these, Ward proposes the theory of spontaneous order, where, 'given a common need, a collection of people will, by trial and error, by improvisation and experiment, evolve order out of chaos' (Ward 1966, p.2).

Agile teams share many of the traits of anarchist practice: they commit voluntarily to ‘do the work’; the work is time-bound; they have a clear goal and usually have between 5–9 members. Referring to World War Two, Ward also mentions ‘leaderless’ groups in the British and American armies who were free to react on the ground to ‘live’ situations and contexts. This has evolved into ‘Mission Command’ (Vandergriff 2017) in NATO, which cedes control in combat situations rather than preserve a chain of command that cannot directly control a situation. It requires SO towards a goal or mission orders within set rules or principles**.** This is similar to Agile organisation, where a team decide how to achieve a given goal, responding to changes and modifying plans as they develop product within the rules of the Scrum Framework. In education, there are parallels with PBL (outputs 2 and 7) and independent learning (output 1), which illustrate a continuum of learner control and agency dependent on whether the intention is SM towards a predefined issue, or SO towards a team-defined goal.

Authenticity and relevance

Connecting learning to authentic contextual issues is key within the outputs. Authenticity is defined as learning that enables students to solve challenging problems in 'real life' contexts, often by working collaboratively (Barnes & Shirley 2007; Lombardi 2007; Roach et al. 2018). I first realised a disconnect between education and its context in 1985, in my first teaching post (as an unqualified teacher) in a Zimbabwe government secondary school. Only five years after independence, I taught O Level history and geography to the children of the Chimurenga (war of independence). It was here that I re-encountered the idea that knowledge was fixed and something to be learned and recounted —with or without

meaning-making. Here, too, was the politicisation of curricula as an entitlement rather than as a means to transform society, and the teacher as unquestioned authority in absolute control of classroom events. In my Zimbabwean post, the curriculum lacked relevance to the needs of society and the contextual reality of children in rural areas. I wonder now if my position as an outsider gave me clarity in this regard. Part of the teaching/learning context was the aftermath of the Chimurenga, which lasted from 1964–1979, and accounted for a reported 20,000 deaths. In the immediate post-war reconstruction following independence, a national education programme that revered academic excellence was introduced, supported by foreign aid and using the Cambridge overseas O level examinations. Ex-fighters were entitled to a free education and I found myself (aged 23) teaching ex-combatants older than I about the history of a war in which they had fought. The fact that my knowledge on the subject was unquestioned made me feel a uneasy about the value of the education being provided. For example, I also taught about the First World War and coastal erosion in a landlocked country. It was clear that the curriculum could not have been less authentic, but nevertheless remained valued as something previously denied, despite lacking connection to the students' reality.

Even so, I sought a connection to authenticity. We made World War One trenches out of desks, drew cliffs, bays and sea stacks in chalk on the walls, and went on field trips to the local dam to look at waves. My motivation was to make it real and alive and to decontrol the students so that they might look beyond books and use their own reasoning and evidence of the world. Despite a disconnect between school and context, a focus on authenticity can connect different forms of evidence and knowledge, which can be applied to actual problems. Authenticity appears similar to

praxis (Freire 1972), in which action is taken in context on real issues to apply and gain knowledge and ideas. In Zimbabwe I wanted learners to work things out for themselves. Outputs two, five, seven and eight, reflect this by attempting to shift control within self-managing frameworks. This theme of authentic curricula, or bringing the outside into the teaching arena, is evident in outputs one, three and seven.

I now recognise that my unorthodox interventions tapped into an aural and oral tradition based on dance and theatre which were a counter to the lack of connection between school-based knowledge and people's lives. Those ex combatant students of the 1980s were incredulous that soldiers would leave a trench and march across no man's land into machine gun fire. This experience made me question the purpose and value of a curriculum that was not culturally situated (to some extent), and therefore exclusive. Outputs 7–8 continue this theme in the Palestinian context.

My time in Zimbabwe impassioned my teaching and learning and, idealistically, the need to make a difference. In Zimbabwe, the British educational system had been imported wholesale into an agrarian economy that desperately needed technicians, as much, if not more than, doctors, scientists, accountants, and government clerks. It struck me that education needed to be inclusive, embrace diversity, and be authentic and relevant to the lived experience of young people so that they were able to achieve, in the words of Sen (1992), a life that they value. This is reflected in outputs 7–8, which focus directly on task authenticity, and 1–4 which align authenticity to digital technology use and learners' digital habits for educational purposes.

Developing learner-centred teaching

Putting the ‘learner at the heart of what we do’ is a common phrase in education, stemming from the concept of user-centred design, and is linked to a learner’s choice in negotiating their education, as if it were a service they control (Leadbeater 2004). My ideas of learner-centred teaching are coupled to agency and the premise where, ‘At the heart of the educational process lies the child. Individual differences between children of the same age are so great that any class, however homogeneous it seems, must always be treated as a body of children needing individual and different attention’ (Plowden 1967, p.25, in Gillard 1987).

In 1987, I trained as a teacher at Lancaster University and my teaching practice transformed my thinking about teaching and learning. I taught history and English as an additional language (EAL) at St Paul’s Way School in Tower Hamlets, part of the Inner London Education Authority (ILEA). At the time ILEA was implementing a policy of inclusive practice in its secondary schools focused on minority ethnic EAL students’ needs, but a term of preparation on my PGCE course was inadequate. My experience in Zimbabwe, where I was used to being listened to and respected, were equally of little help. My first class was integrated in terms of ability and ethnicity; the majority were new arrivals from Bangladesh, with a few white and some black and mixed-race children. The school used the Schools’ Council History Project (SCHP), devised by Stenhouse (1968), as a comparative history stance, and the topic was the American West. I had prepared what I thought was a great worksheet with visuals and text, only to find that the students could not read it. I recounted my experience to my mentor, and she referred me to the EAL specialist, who recommended I visit the Collaborative Learning Project (CLP). This specialised in

interactive social learning. ILEA at the time was well resourced with very low teacher-student ratios and a variety of peripatetic specialist staff in several disciplines, including EAL and translation (HMI 1980). The EAL specialist showed me how to make texts accessible for learners and the CLP introduced several techniques through which students could solve problems collaboratively. This revealed to me how teaching might work from the perspective of the learner. I realised that collaborative-learning was both effective and enjoyable and it informed my educational philosophy of ensuring access to opportunity and a developmentalist approach (Fenwick & Edwards 2012), (outputs 1–4). However, moving to a method that supports diversity multiplies the demands on a teacher, being both time consuming and difficult. Instead of one lesson, an educator must facilitate several, requiring different skills, roles and identities, as outputs two and seven discuss.

In practice, my ‘new’ learner-centred, goal-focused designs increased engagement and interaction, and I now see that the release of control and agency towards the learners was enabled by elements of SO in the activities. ILEA actively supported experimentation and innovation in education and the techniques were backed by both research, and policy. In hindsight, the positioning of ‘methods of learning’ as technologies in output five has its origins in my early use of collaborative-learning techniques.

Having strayed unwittingly at the time into learner-centred teaching design, it was not until recently (output 7) that I started to see such methods/mechanisms as being agentic actors in the-learning process. The design of non-human actors (e.g. work sheets, fact sheets, problems) is important because it shifts student interaction

directly to the content, rather than being directed and mediated by a teacher. With learner-centred design, students are required to create, transfer or translate knowledge rather than passively receive it. This is similar to Latour's (1990) notion that actors combining in a network are both transformed and transforming of each other. At the time, learning technology was limited to a video, photocopier and bander machine. The latter two afforded personalisation and group working but more in a sense of assisting the overall collaborative design; they were actors which combined with learners to make activities possible.

Making learning accessible, increasing opportunity to education and employment.

After working as an EAL teacher for several years, I studied for an MA in Education (1992) in teaching English to Speakers of Other Languages (TESOL). Here, I had a first encounter with the work of Paulo Freire (1972) and the banking concept of education; it was a moment when many aspects of my practice suddenly made sense. Freire deconstructed the idea that education saw students as being in deficit and bring nothing to the classroom. This reinforced my belief in student-centred collaborative practice, and I also became interested in game-based learning with inbuilt intrinsic goals or win states (evidenced in output 1). To this end, I designed a computer-assisted language-learning (CALL) game in which I replicated a learning design from my time in the ILEA. The MA programme pivoted my practice around the notion of functional 'grammar in context' that I learned. This split English into text types with different patterns of grammatical markers and items dependent on communicative purpose. It was a technique based on core communicative functions

of texts, which allowed learners to focus on the grammatical structure without removing meaning, hence ‘grammar in context’ (McEldowney 1982). This leant itself to ‘functional’ English and I was able to combine my work on collaborative and group learning by writing materials which made vocational subjects accessible. This practice provided access to education for those with diverse backgrounds and needs, so that they might ‘function’ in the economy. I became set pragmatically on providing equality of access and opportunity through education. This stance is clear in outputs 1–2, which are partly about widening the curriculum and learners’ skill sets to enable access to life and work opportunities (output 3).

This method of making vocational practice accessible led me to work in an inner-city London further education (FE) college. Here, in charge of language development with over 70 staff and 250 courses, ranging from hairdressing to electronic engineering, I propagated the method at scale. At the core of the initiative was students’ ability to do things for themselves and in collaboration, which is key to learner-centred practice (outputs 2, 7–8). The CA (outputs 3, 5–8) is also relevant as the mechanisms or techniques used allowed greater access to education for all participants in the class; EAL students remained in the vocational context, allowing them to become vehicle mechanics, care workers or whatever other vocation they valued. This, arguably, changed the context of learning so that the capabilities of participants could be more readily converted into valued functionings. The technique unlocked the standard forms of English as a way of enhancing individuals’ capabilities within the educational setting and was enough to access what Bourdieu (1991, p.45) called ‘The official language [... or] the theoretical norm against which all linguistic practices are objectively measured’. On reflection, I was aware that literacy

was a contested area and that it was, clearly, socially constructed and tied to constructs of power (Freire 1972; Bourdieu 1977; Giroux 1983; Street 1995; Gee, 2000; Barton 2001) as well as being broader than the ‘language of education’. However, I took a pragmatic view that access to the language of power through communicative competence was probably more important than recognising the ideological stance of multiple literacies and critical pedagogy. If students could acquire the language necessary to pass their City and Guilds, I could live with them acquiring symbolic power later. The linguistic diversity of the students (over 70 different language groups) and the predominance of refugees made an experimental approach vital for learner engagement. At this point, I started to become interested in how organisational systems and processes could support or develop the learning context (outputs 7–8). I focused on system constraints which denied students access to opportunities (outputs 1–2, 4) and used team teaching to propagate a method that allowed them to achieve.

Learning in digital environments.

From 1994 whilst working in London in FE, I started to apply digital technology to teaching and learning. Around 1996, I became interested in computer games and learning. I helped my nine-year-old son, who was aurally dyslexic, to read using a commercial computer game called Fable (1996) (Fig. 4) —a puzzle discovery/adventure game which had clues voiced by an in game character, but which also appeared in speech bubbles on the screen. This repetition due to not being able to work out the solution and the avoidance of phonics (which he could not distinguish aurally), taught him to read using a whole word method.

Figure 4. Fable, by Simbiosis Interactive (1996)

I realised that games were potentially powerful yet immersive-learning designs (Prensky 2000), exemplified in output one, in which a particular group activity was successful due to the resource-based 'game grammar' children had derived from their digital habits (Gee 2003, 2005). In 1999, I was commissioned by the National Learning Network (NLN) as an associate of the Language Development Network (LDN) to develop online core skills materials with an e-learning company called Desq. We tried to create immersive-learning environments with our learning design 'The Street' for the NLN (2000), using characters and scenarios in a 3D world, who had to complete various communication tasks. This was modelled on Habbo Hotel (Fig 5.), a popular 2D render of a 3D world and a social network.

Figure 5. Habbo Hotel, the design reference for ‘The Street’ for NLN (Fig. 6)

Figure 6. Part of ‘The Street’ for NLN (2000)

Unfortunately, our idea of immersion in a game world was not possible due to the Sharable Content Object Reference Model (SCORM) which required disaggregated content or ‘learning objects’ that could be re-used and repackaged within a learning management system (LMS) that tracked learner completion and performance (Witthaus 2009). This led to the replication of content-based learning rather than the immersive discovery learning we wanted. Output three considers how computers in education can lead to the industrialisation of e-learning, and the SCORM object packaging certainly bore witness to that. Our learning design was rendered as pages of content whilst the immersive element was just an animation that ran on top of a menu (Fig. 7).

‘The Street’ was intended to mirror the immersion found in games and what Gee (2003) calls engagement with a domain of meaning and players have to learn as characters in the environment, a concept that Gee calls ‘authentic professionalism’ which I refer to in outputs five and seven.

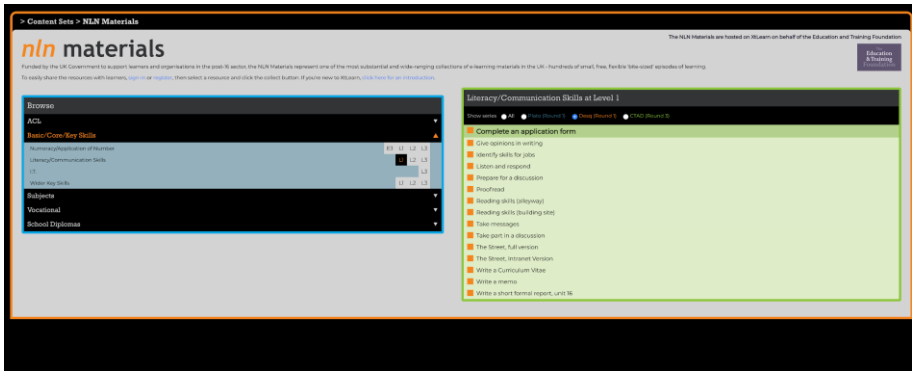

Figure 7. NLN Learning materials for ‘The Street’

In 2000, I started work at Wolverhampton University as head of post-compulsory teacher education. I became interested in commercial games and the learning embedded within them, and started writing on this theme, originally in trade journals but later both academically and for the British Educational Communication Technology Agency (Becta —a government-sponsored body for the promotion and integration of information and communications technology (ICT) in education) (Royle & Clarke 2003; Royle 2008, 2009; Royle & Colfer 2010). My motivation for using games, initially driven by bringing the world of the learner into education, was becoming more about learning and how and where that occurred best. Outputs 1–3 and five whilst still digitally focused also illustrate a movement towards the creation of learner-centred designs.

Around 2005, I switched roles and began working on funding bids, project direction and research. Through my teaching on an MA programme, I created a module on learning in the digital age, allowing me to transfer scholarship and research into learning. Initially, this reflected my interest in digital technology as intervention and the digital habits of learners, but has progressed to issues of pedagogy and its relationship with technologies; more recently, the module has become entirely

problem-based. This mirrors the progression of the (project based) outputs, starting with technology interventions, (outputs 1–2) focusing on laptops and games consoles, through to mobile devices (output 3), learners' digital habits (output 4), and considerations of pedagogic interventions (outputs 5–8).

Actor network theory

My first encounter with ANT (Callon & Latour 1981; Latour 1987; Law 1994) occurred whilst talking to my younger son in 2018, about his design-based degree involving speculative design (Dunne & Raby, 2013) and actant switching (Foley & Lockton, 2018). I combined this with the Agile systems thinking approach (Larman & Vodde 2009) I had been learning about in my industry certification. I realised that ANT analysis could be applied to my outputs to consider a wider scope of human and non-human actors, and their influence in forming a network. ANT is predominantly used for contextual analysis rather than as a model to be applied generically (Cressman 2008), but can also analyse past events and networks (Callon, 1984; Latour 1987, 1988). It is also arguable that ANT could be used for designing future socio-technical networks towards a defined goal in education. This will be explored in more detail below and in the conclusion.

Framing the analysis of the outputs using ANT

This section outlines the components that I will employ to discuss the outputs further through retrospective analysis. Callon proposes three principles of ANT: 'agnosticism (impartiality between actors engaged in controversy), generalised symmetry (the commitment to explain conflicting viewpoints in the same terms) and free association (the abandonment of all a priori distinctions between the natural and the social)'

(1984, p.1). These principles act as a guide so that I might recognise my positionality in the analysis. Other key aspects of influence in forming the outputs (human agency, capability and definitions of technology) are also considered in more detail here as arbiters of the effect of interventions and as potential future actors in the proposed learning design scaffold. For example, did the interventions lead to increased AF and the conversion of capabilities into functionings, and how might different 'technologies' contribute to transformation in learning and teaching? Subsequent sections involve a detailed analysis of output one to exemplify how I have chosen to apply ANT (using the ANT toolkit, below) and brief retrospective analyses of each following output to highlight aspects of each paper. I focus on particular themes, discuss how my positions occurred and were developed, and consider how each output influenced my thinking. Further, I consider the effect on curricula, pedagogy or assessment, and any wider systemic effects of each intervention.

Turning over interesting stones with ANT

Law (2008) states that, rather than being seen as a theory, actor network theory (ANT) should be treated as 'a methodological toolkit, a set of practices for inquiring, turning over interesting stones, tracing links, and most of all, of following unexpected leads and connections, that is, developing opportunities for creating learning and innovation' (Law 2008, p.4). As such, ANT appealed to me as a toolkit for retracing my steps through my outputs to see what could be learned. In fact, using ANT to unravel and draw connections between research approaches used was, in a metacognitive sense, invaluable as it allows consideration of different perspectives. ANT, contrary to my earlier thoughts that there was 'no agency in technology' (output

1), ascribes agency to all sources of action, whether: ‘An actor in ANT is a semiotic definition —an actant —that is something that acts or to which activity is granted by another [...] an actant can literally be anything provided it is granted to be the source of action’ (Latour 1996, p.373; Callon & Latour 1981, p.286). In ANT, the social fabric —organisations, people and indeed education —is nothing other than patterned networks of heterogeneous materials (Law 1992). Law (1992) notes:

> networks are composed not only of people, but also of machines, animals, texts, money, architectures —any material that you care to mention. So, the argument is that the stuff of the social isn't simply human. It is all these other entities too. Indeed, the argument is that we wouldn't have a society at all if it weren't for the heterogeneity of the networks of the social. So, in this view the task is to ‘characterise these networks in their heterogeneity and explore how it is that they come to be patterned to generate effects like organizations, inequality and power (Law 1992, p381).

ANT calls this heterogeneity ‘symmetrical analysis’ or ‘generalised symmetry’, a principle where ‘the material and non-human elements of any network should, in terms of analysis, be treated in the same way as the social and human elements’ (Somerfield 2020, p.4). Non-human actants can become actors and have a form of agency that allows them to act upon others within a network (Fox 2005). In forming a retrospective of the outputs, ANT facilitates the consideration of that which was not previously considered, so that the researcher becomes an actant in the network. This is a position I had not previously fully considered, and I realise that my interpretation of that role is also part of the retrospection. As such, I acknowledge that the accounts and analyses that follow are perceptions of times past, and that I

(even with the ANT toolkit and sometimes because of my interpretation of it) have consciously ‘cut the network’ (Strathern 1996) by including certain actors and excluding others. This is part of the reflexive act and such awareness (as far as possible) is, I hope, endemic within an ANT analysis, extending my retrospective reach and making visible entities unconsidered at the time. As Fenwick and Edwards (2012) note, ‘Wherever one marks boundaries around a particular phenomenon to trace its network relations, there is a danger of both privileging that network and rendering invisible its multiple supports’ (2012, p.6). Lynch (2000) also notes that ‘Reflexive analysis is often said to reveal forgotten choices, expose hidden alternatives, lay bare epistemological limits and empower voices subjugated by objective discourse’ (Lynch 2000, p.36). It is easier to see this metacognitively with ANT because of the identified presence (of the researcher) placed within a wider network of actors. Indeed, Law argues that our interaction in networks defines the social, and he uses an analogy of the lecturer and projector as acting to define the relationship between students and teacher: ‘The projector, like the shape of the room, participates in the shaping of our interaction. It mediates our communication and it does this asymmetrically, amplifying what I say without giving students much of a chance to answer back’ (Law 1992, p.382). When I read this, it shaped my understanding of ANT and how it worked in regard to teaching and learning and was similar to Monahan (2000) in output 7.

Fenwick and Edwards (2011) also support an ANT approach to unravelling complexity, stating that, ‘ANT’s language can open new questions and its approaches can sense phenomena in rich ways that discern the difficult ambivalences, messes, multiplicities and contradictions that are embedded in so

many educational issues' They further note that the goal of ANT is to understand 'how these things come together—and manage to hold together—to assemble collectives or "networks" that produce force and other effects: knowledge, identities, routines, behaviours, policies, curricula, innovations, oppressions, reforms, illnesses and on and on' (Fenwick & Edwards 2011, p.3).

Critics of ANT argue that, by ignoring factors of race, class and gender, *inter alia*, it cannot effectively challenge issues of power and inequality (Harding, 2008; Bloor, 1999; Restivo, 2010). According to Restivo (2010), ANT dismisses the notion of the social as too opaque (as a received or given state that can be applied to any circumstance). However, I would argue that ANT does not dismiss such classifications; rather, it invites us to see them at work within networks —how they are translated within action and actors, how they are recruited to act in a certain way, as well as to look for evidence of their action. In this regard, Fenwick suggests that, 'No anterior distinctions such as "human being" or social "structure" are recognized —everything is performed into existence' (Fenwick 2010, p.120). As Law notes, 'actor-network theory is all about power —power as a (concealed or misrepresented) effect, rather than power as a set of causes' (Law 1992, p.387), manifest through the various actors in a network and how they are constructed and held together.

In summary, an AN is a patterning of heterogenous actors that are dynamic, and the points of interest are how they are assembled and how they hold together through relational effects that may result in organisation, inequality and power. Importantly, ANT does not have a topographic view of networks —it does not give them shape or define them by their system. As Latour (1996, p.5) suggests, 'the type, number and

topography of connections is left to the actors themselves'. A network in ANT is therefore defined by the actors, i.e. those that contribute are the network (Latour 2005). Fenwick and Edwards (2012) agree, warning that the notion of technological networks implies they are a group of fixed points often defined by what travels between them. The same authors note that these points are often seen as innocuous and easily defined without power relations. Indeed, (Pendleton-Jullian & Brown, 2018) detail the different configurations of network topographies and map the constituent members of various social networks. However, whilst this reveals their shape and number of connections, it does little to describe action, consequence, power relationships or purpose. In this regard, ANT can be used to shed light on such information.

ANT's symmetrical analysis maps the territory of education while uncovering goals and agendas by disaggregating its actors and recognising its alliances. For example, Hayes and Jandrić (2014) state that 'information and communication technologies interlocked with global neoliberal capitalism have strongly territorialized the contemporary university' (Hayes and Jandrić 2014, p.197). ANT can be used to examine this notion by making policy discourses transparent. Similarly, in its heterogeneity, ANT debunks binary oppositions of technological determinism versus human agency and, as such, notions of 'technology', central to this retrospective, are defined and expanded next.

What constitutes technology?

A heterogeneous view of technology requires conceptualisation that is wider than the digital, which commonly centres on tools (virtual learning environments (VLE), software, and objects (mobiles, tablets, consoles). Cramer (2015, p.2) defines the

post-digital as ‘either a contemporary disenchantment with digital information systems and media gadgets, or a period in which our fascination with these systems and gadgets has become historical’, and this allows a focus on human relationships with technology within society. Post-digital definitions of technology fit well with ANT, in seeing it ‘not simply as instruments to serve economic ends, but as sociotechnical systems, which do not operate in isolation from human labour, language, politics, or morality’ (Hayes & Jandrić 2014, p.199). ANT assumes that ‘each actant is in itself an actor-network; who, through its own translations involves the participation and involvement of other actors’ (Burga & Rezania 2017, p.1026). Output five develops a wider view of technologies by making reference to ontologies of technology (McGinn 1978; Mitcham 1994; Arthur 2009), settling on Arthur’s broad definition as ‘a means to fulfil a human purpose […] as a means, a technology may be a method or process or device’ (Output 5, p.37). Herschbach (1995) draws attention to dualism in technology by referring to its usage in French, where ‘Technologie is used to refer to the study of technical processes and objects, and the term "technique" refers to the individual technical means themselves, the actual application processes’ (Herschbach 1995, p.2). This highlights the distinction between ‘technology as knowledge, technology as activity and technology as object’. These definitions open possibilities about how humans create and work with and alongside ‘technologies’ beyond technology as an object. ANT includes technologies as actors/actants in a network by ascribing to them agencies and ways of acting with others. Each actant also brings with it other actors in its own ontological network, the ‘unpacking’ of which can reveal the design or policy that created it. For example, the world wide web would not exist without government funding (Naughton 2016).

Using ANT gives a different perspective to the how and what of technologies and their purposes within a network. Importantly, to recruit technology to a network, it needs to have affordance, defined as the range of possibilities for action as prompted by an object within a context, and by how humans perceive that possibility (Gibson 1977; Norman 1988). Similarly, Laet and Mol (2000) suggest that where an object has several fluid identities, depending upon the agencies it creates with others, ‘an object that isn't too rigorously bounded, that doesn't impose itself but tries to serve, that is adaptable, flexible and responsive in short, a fluid object —may well prove to be stronger than one which is firm’ (Laet & Mol 2000, p.225). Whilst McGinn (1978) notes that technology is purposive, Latour (2005) adds agency by noting that ‘things might authorise, allow, afford, encourage, permit, suggest, influence, block, render possible, forbid and so on’ (p.72). The notion of affordance is extended beyond the human perception of objects or everyday things (after Norman 1988,1990) into how actors/actants in a network are connected and recruited to act or act back against the proposition that may attempt to form a network.

Agency and capability

Alongside the wider definition of technologies as equal actors in any network, human agency is a concept central to the outputs’ narrative arc (see output 1, 5–6). This is Bandura’s (2001, p.2) definition of human agency as an individual’s ability to ‘play a part in their own self-development, adaptation, and self-renewal with changing times’, and the notion of AF underpinning the CA (Sen 1992; Robeyns 2005; Nussbaum 2011). Capabilities are the beings and doings (functioning), or the ability to achieve and the achievements of a person (Sen 1987), while AF is how their ways of being and doing are expanded through a choice of options. Nussbaum (2011,

p.290) notes that capability means ‘opportunity to select [...] the notion of freedom to choose (AF) is thus built into the notion of capability’. Sen does not define human capabilities or functioning realising that these are contextual, circumstantial, and often delimited by culture. Others have equated capabilities with human rights and equalities frameworks (Nussbaum 2011; Burchardt & Vizard 2009; Burchardt & Hick 2018). The CA in outputs three and 5–7 facilitates thinking about how humans are able or otherwise (due to contexts or systems, cultural frames or structural inequalities) to achieve a life they value. What someone ‘can or cannot actually do’ (Sen 2009, p.261) is subject to variation according to their characteristics (gender, age, disability etc.) and the social and environmental conditions of any given society, i.e. ‘conversion’ factors. Education, according to Robeyns and Nussbaum, respectively, is key to human capability. ‘Being knowledgeable and having access to an education that allows a person to flourish is generally argued to be a valuable capability’ (Robeyns 2006, p.12), as long as ‘education is of high-quality and aims at the development of the full human being, instead of stunting children in their emotional, personal and intellectual development’ (Nussbaum 2003, quoted in Robeyns 2006. p.13). As Robeyns notes, the CA ‘can be used to evaluate several aspects of people’s well-being, such as inequality, poverty, the well-being of an individual or the average well-being of the members of a group’ (2006, p.12). In the context of this narrative, the CA can evaluate educational interventions to see whether they increase AF and are equitable. The nature, intent and outcome of the intervention is therefore important, and ANT affords this analysis.

Alkire (2008) uses the example of a bike to illustrate how capabilities can be converted into valued functioning:

Resource: A bike > Capability: Able to ride around > Functioning: Ride around > Utility: Happiness.

The bike is a non-human actor (Latour 2005) with a perceived affordance (Norman 1990) of riding around. However, the CA adds extra layers concerning equality and the freedom to choose to use the affordance, in that there may be contextual constraints upon certain groups or individuals. ANT can be used to examine the goals of each actor and the purpose of the network as a whole. Although the bicycle affords the function of riding around, the actors acting against riding around may be stronger. The importance of this is that the bicycle/resource only adds capability if it enhances the beings and doings of a person. This may mean, in some societies, that young men can use the bicycle to find work but young women do not have the freedom to travel beyond the immediate neighbourhood, and so cannot convert capability into functioning (find work). The CA notes that, even where recipients have resources and a high standard of living, they may be limited in their life choices. For this reason, 'Instead of asking about people's satisfactions, or how much in the way of resources they are able to command, we ask, instead, about what they are actually able to do or to be' (Nussbaum 2000, p.12). If for 'cultural' reasons, girls are not allowed to ride bikes then this capability is constrained; the same is true if children cannot access the education system because of how they are taught. What ANT affords is an investigation of who and what acts; once armed with this information, other actors may be introduced to create a different contextual effect. A good example of the interplay between ANT and the CA can be seen with household income. A household might be judged prosperous against norms for a region based on a total income figure, but how the income is distributed amongst household

members may mean some cannot convert capability into functioning. Using ANT to look at the various actors in such a network may illuminate how things can be changed.

Robeyn (2003, p.64) acknowledges this, stating that whilst capabilities and functionings are the properties of individuals, social and environmental conversion factors are also important. Thus, the CA can be used to examine equality of outcomes for educational interventions, whilst ANT assists the interrogation of how those outcomes are reached (or not) through various actors and particular goals.

According to Fenwick and Edwards (2011), human intention and action is decentred in an ANT approach, but in all of the outputs it is central to proceedings and seen as a positive outcome of the interventions. In the outputs, I considered limitations on agency as an imbalance in several factors: power relations between teachers and learners (output 7); teachers, learners and organisations (output 4); and, organisations and government policy (outputs 3, 6). The creation of space for learner and teacher agency is crucial to any educational project in this regard and outputs 6–7 directly consider how human agency is central to any educational project.

In retrospect, the outputs focus asymmetrically on human agency, both centrally and tangentially. An ANT-based perspective allows a more comprehensive proposition of how change might occur, and impact be evaluated. ANT traces the associations between different actors within a dynamic and situated network (Suchman 1985), taking little account of ‘plans and intent’ except as actors in a network. Law (1992) notes that agency always results from human and non-human actors combining

through network associations, whilst Latour urges examination of the detail behind interventions:

> Without accounts, without trials, without differences, without transformation in some state of affairs, there is no meaningful argument to be made about a given agency, no detectable frame of reference. An invisible agency that makes no difference, produces no transformation, leaves no trace, and enters no account is not an agency. Period. Either it does something or it does not (2005, p.53).

This registering of agency in the accounts of actors within the outputs is fundamental to this analysis, and increased 'AF' and resulting capability/functioning are part of this. The next section examines how this can be achieved.

Analysing using the ANT toolkit

ANT provides several conceptual tools as part of an analytical ontology. **First**, the notion of **punctualisation** allows actors in networks to be simplified from their own constituent ontologies so that they can be single actors within a particular assemblage (network) (learners in output 2). For example, a TV in an older person's home is a communication device, a source of companionship and entertainment. It is an actor in their network as much as the health visitor, milkman and so on. It is never a complex network of components and electrical parts and likewise the programmes that screen on it are never broken down into their constituent parts; to do so, would simply be too complex to contemplate or describe. If the TV breaks and needs repair, it no longer functions in the network and its complexity may become visible (to a repair person). ANT accepts this simplification of the complex to define the actors within a network. Law calls these parts of a network 'resources' and they are stable

at the point of use, but can become unstable. Such resources, according to Law, can be: ‘agents, devices, texts, relatively standardised sets of organizational relations, social technologies, boundary protocols, [and] organisational forms’ (Law 1992, p.5). Law uses the analogy of the human body, where:

> if a network acts as a single block, then it disappears, to be replaced by the action itself and the seemingly simple author of that action […] At the same time, the way in which the effect is generated is also effaced: for the time being it is neither visible, nor relevant. So it is that something much simpler —a working television, a well-managed bank or a healthy body — comes, for a time, to mask the networks that produce it (1992, p.5).

Second, and coupled with punctualisation, is the notion of the **‘black box’**. Actors in a network can also be ‘black boxes’ (Law, 2007), as complex networks themselves are imported into a system and the actant is not reopened or questioned (outputs 4, 6). The actant functions within the network and ‘does what it does’. Black boxing allows complex networks to be bundled as actors within another network. A black box can be an actant once it has undergone the process of punctualisation. A curriculum, for example, is generated by policy and ideology and what it excludes is as important as what it includes (*see* Clarke 2018, p.8). At some point, it is punctualised and becomes a black box which ‘contains that which no longer needs to be considered, those things whose contents have become a matter of indifference’ (Callon & Latour, 1981 p.285). Complex constructs such as neoliberalism or globalisation (output 3) can be black boxed as far as they act within each output, and this is a useful tool in ANT because it allows a focus on those that act to transform. As Law (1992 p.5) notes, ‘All phenomena are the effect or the product of

heterogeneous networks. But in practice we do not cope with endless network ramification. Indeed, much of the time we are not even in a position to detect network complexities'.

The **third** tool for analysis of an AN is **translation**. Law (1992) calls this the core of the AN approach and it is the act of network creation and maintenance —an ongoing process where actors can combine or separate. Translation is about how this occurs, how actors are persuaded to unite to act (see output 7), and how resistance is overcome (Law 1992). This may be confused with bounding the scope of a system (Pendleton-Jullian & Brown 2018). In this case, an area of study is formed by placing a boundary around something and looking at the system within, 'defining the context within which system components and agents interact' (Pendleton-Jullian & Brown 2018, p.265). In ANT, the actors that do things or recruit others to their purposes in the network actually create the boundary of the 'system'. The network is never taken for granted and Law (1992, p.6) notes that translation is 'a concern with how actors and organisations mobilise, juxtapose and hold together the bits and pieces out of which they are composed; how they are sometimes able to prevent those bits and pieces from following their own inclinations and making off'.

The four stages of translation

Callon's four stages of translation (1984) have been critiqued (Fenwick & Edwards and others 2011) as too commonly used as a 'fixed model', in an approach that attempts to describe complexity in which nothing is ever 'sewn up' (Law 1992). However, within the 'model' of translation is the idea that networks form around a

problem or for a purpose, similar to the ideas that support SO. Law (1992) notes that ANT can also analyse the powerful and demystify how particular relationships arose and are maintained. These notions are relevant to the analysis of the outputs. The reasons why networks exist and how they are maintained is as pertinent, for example, as thinking about how new ones may be formed.

Stage one: Problematisation. In this stage, the reason for network formation is defined and outlined and the key actors in the network identified. One set of actors seek to include and recruit others to identify with the problem (see outputs 1–2). Each network member attaches themselves to the problem by defining a goal which is not at odds with others' goals, but works collectively towards the problem. The goals or motivations may be different (output 2) but, overall, the course of action is enabled by overriding other connections. As Callon notes, 'Each entity enlisted by the problematisation can submit to being integrated into the initial plan, or inversely, refuse the transaction by defining its identity, its goals, projects, orientations, motivations, or interests in another manner' (1984, p.8). Callon calls this the **obligatory passage point**, where actors/identities must latch onto the problem by defining solutions that encourage them to form alliances to achieve their distinct goals collectively.

Stage two: Interessment. Recruited actors relinquish conflicting interests to focus on the solution to the problem, by committing to a particular course of action.

Stage three: Enrolment is how the actor's presence in the network is consolidated and how they are persuaded to assume roles in the project. Callon (1984, p.10) notes, that 'No matter how constraining the trapping device, no matter how convincing the argument, success is never assured. In other words, the device of

interessment does not necessarily lead to alliances, that is, to actual enrolment'. Subsequently, according to Sommerfield (2020), the commitment to the course of action is then 'enforced through the necessary means (inducement, persuasion, manipulation etc.), following which, the course of action is enacted'.

Stage four: Mobilisation is when a second set of actors engage with the problem and believe in its purpose, outcome and consequences. Callon (1984) asks, 'Who speaks in the name of whom?' Who represents whom? These crucial questions must be answered if the project is to succeed. In Callon's scallop fishing example, he notes that representatives of fishermen speak for all fishermen in their commitment to the project, harnessing their collective agency beyond the initial commitment of the individual scallop fishermen of St Brieuc Bay, who seek to preserve their livelihoods and the reproduction of the species in sufficient numbers. Thus, the project has expanded its network beyond its original alliance and issues of structure and power established. Law (1992, p.3) notes that '"translation" is a verb, which implies transformation and the possibility of equivalence, or the possibility that one thing (e.g. an actor) may stand for another (e.g. a network)'. Further, Fox (2000, p.863) notes that actors may 'act back' in ANT and 'practitioners act as one piece within an assemblage of actants, non-human as well as human, to build networks and chains which achieve certain ends, while recognising that both human and non-human materials have resistive agency: the capacity to act back, granting or refusing translation.' Some teachers in output 2, for example, refused to be involved in the project. Somerfield (2020) stated that 'during the process of translation, networks can move in two different directions, divergence (spaces of negotiation) or convergence (spaces of prescription)'. (Somerfield 2020, p.7).

A **final** but important element of the ANT methodological toolkit is the notion of **intermediaries and mediators**. This describes how actors might operate and has bearing on how translation is achieved or an innovation developed, assimilated and stabilised as a new orthodoxy. As Fox (2000, p.863) notes, 'the important point is that if an actor wants to grow it must enlist and mobilise all kinds of heterogenous links'. Latour defines intermediaries as actors that, 'transport meaning or force without transformation: defining its inputs is enough to define its outputs. For all practical purposes, an intermediary can be taken not only as a black box, but also as a black box counting for one, even if it is made of many parts'. However, he also notes that mediators 'cannot be counted as just one [...] their input is never a good predicator of their output; their specificity has to be taken into account every time. Mediators transform, translate, distort and modify the meaning of the elements they are supposed to carry' (Latour 2005, p.39). This distinction is crucial to the analysis of the outputs, which sought to change the educational status quo. Output seven, for example, considered the use of PBL to replace more didactic pedagogy in Palestinian higher education (PHE). The insertion of PBL into a stable system created changes in three previously stable elements: curricula, pedagogy, and assessment. These effects align with the definition of a mediator rather than intermediary because of their transforming/translating influence on other actors. Somerfield notes that intermediaries 'form faithful stable networks (black boxes), which is when a network enters a dominant phase and where its potential for extending learning and innovation is dramatically reduced. Mediators, on the other hand, are more intrusive, disruptive and creative' (Somerfield 2020, p.8).

Looking at the intention of each intervention in the outputs, and the actors' status as intermediaries or mediators within a network, may illuminate how interventions were ultimately impactful and sustainable or not. In contrast to PBL, for example, the use of flipped learning (outputs 7–8), whilst enabling learners to become more engaged with learning, had little wider effect on other aspects of education. Flipped learning enhanced the existing delivery rather than affecting any further transformations in curricula or pedagogy. The notion of mediator is similar to Pendleton-Jullian and Brown's concept of 'mechanisms of transformation' in their work on complex systems (2018). They stated that change must be designed, and by creating and using mechanisms in a network, perhaps swapping out or applying mechanisms at certain points, such a change can be scaffolded through the network. They categorise mechanisms as 'things that do work […] and are processes or techniques that operate at the tactical or operational level' (Pendleton-Jullian & Brown 2018, p.281).

This notion of putting things into a network and taking things out is interesting seen alongside ANT, which has a similar notion, that 'no version of the social order, no organisation, and no agent, is ever complete, autonomous, and final' (Law 1992, p.6). Where they differ is in how networks are configured; a 'network' for Pendleton-Jullian and Brown (2018) already exists topographically and only needs a boundary to be drawn around it.

The following sections use the ANT toolkit to explore the goals, purposes, actors, agencies and issues from the outputs arising through retrospection and what change if any, may have occurred as a result of each intervention.. In the analyses that follow, I have represented each AN (AN) graphically (see Fig. 9. below) to show

additions and connections for visualisation purposes; these are snap shots in time and do not indicate that the relationships are fixed. Equally, I recognise my hand in creating and realising them. The first output is analysed in detail to exemplify the ANT toolkit further and show its application. Subsequent outputs focus on particular issues of analysis and draw out effects on either curricula, pedagogy or assessment.

Output 1. An Actor Network Analysis — what acts and what does not?

Output 1. Royle, K. Jenkins, C. Nickless, J. (2010) 'Combining analogue realities and digital truths: Teaching kids how to hold productive learning conversations using PictoChat on the Nintendo DS,' *RJET* Ohio: Kent State University Press, 6,(1) pp.76-93.

In the analysis of output one, I discovered how one actor can speak for others and how power is accrued through punctualisation and black boxing. It also considers how actors are included/excluded, leading to othering and how researchers are complicit or active in this process. It also realises that ANT is an empirical process and examines cognitive planning versus situated action.

A primary class has its first encounter with handheld technology

The context for output one was a primary school in a large housing estate in Telford. At the time of the project, there was interest in the use of handheld electronic devices in schools to improve learning outcomes for students. The Nintendo DS, a handheld dual screen console that had sold over a million units in the UK, was used in the project on a closed network in schools (Fig. 8). Its content was restricted to

‘educational titles’ such as Dr Kawashima’s *Brain Training* (Nintendo 2006), which helped to validate their use in classrooms.

Figure 8. A Nintendo DS console

DSs were not designed for school use but their popularity with children and the legitimisation of ‘educational games’ (Gee 2003, 2005; Royle & Colfer 2010) meant they had legitimacy and ‘learning status’ (see output 2). The school had already used DSs and a teacher had reported increased motivation, improved attainment in maths, and better attendance at school as a result. The DS generates its own closed wireless network and has a built in ‘PictoChat’ facility which can link up to 16 consoles in four separate chat rooms. This was quickly discovered by the children and so PictoChat was banned during lessons. Different affordances (Gibson 1977) were perceived in the DS (by teachers and children), and whilst teachers saw it as an engaging, non-threatening tool whose software aligned with learning objectives, children saw it as a communicator for sending messages without the teacher knowing. Latour’s (2005) distinction of mediator and intermediary can be applied to the different affordances of the Nintendo. The introduction of the non-human actor had unintended consequences. Figure 9 shows an initial schematic AN for the use of

the Nintendo DS in learning that I created (for this retrospective) from the initial scoping of the research project with staff and students at the school.

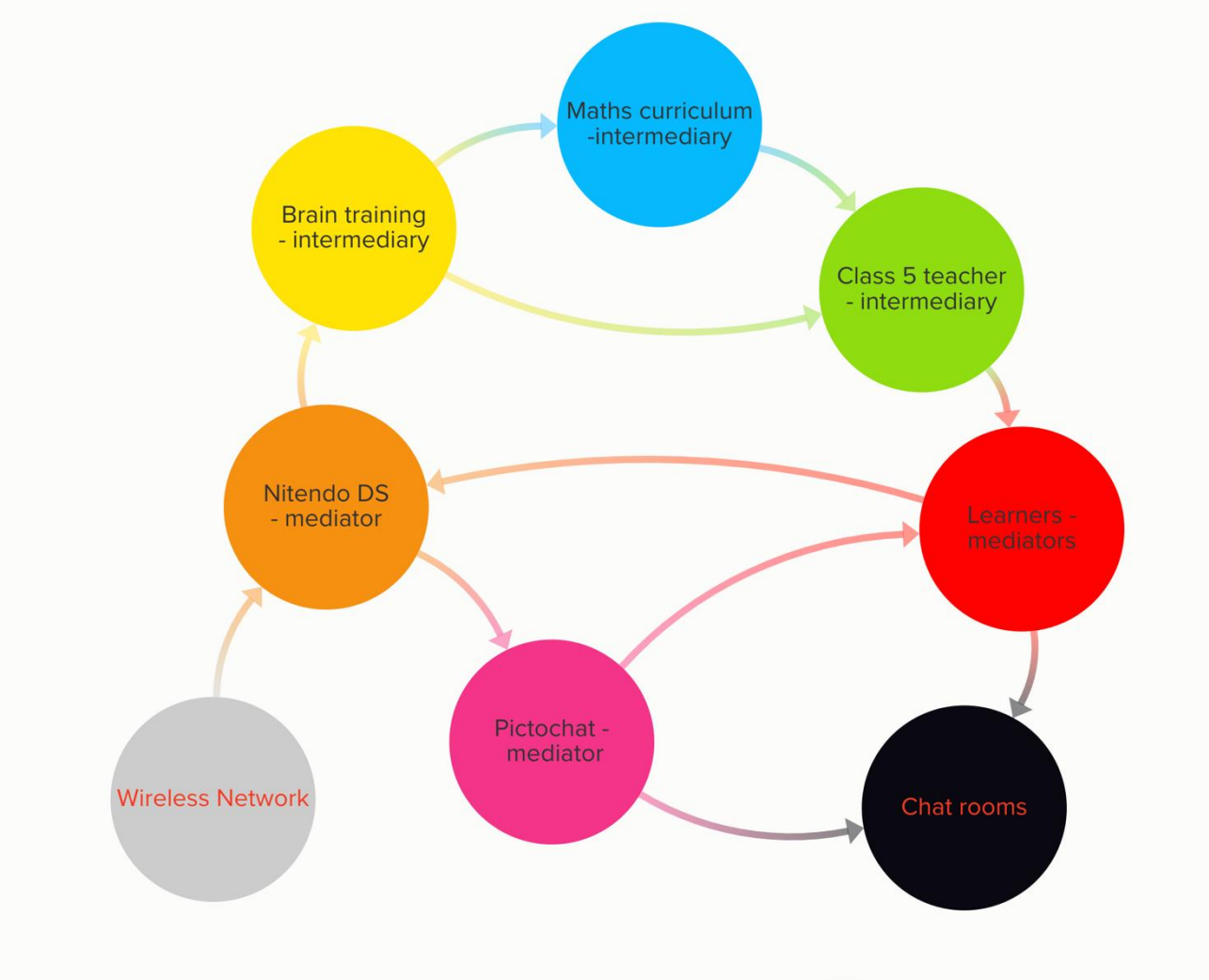

Figure 9. Initial AN schematic

Here, the wireless network acts as a black box and intermediary. The teacher, controlling the classroom, is also an intermediary, as is the maths curriculum and the Brain Training software. The learners, PictoChat, DS console and chat rooms are classed as mediators because of the transformation of both the intended purpose of use and the methods involved (Latour, 2005). Law (2007) notes that ANT practitioners are more interested in how things happened than why things happened. By using ANT, we can see how the actant (DS) (intervention), despite being

perceived as an intermediary, a ‘delivery mechanism’ to enhance maths performance, actually acted as a mediator because of its different affordances and fluidity (i.e. ability to assume different roles for different actors) (Laet & Mol 2000). For the teacher, it was a delivery system beloved by the learners because of its status in their home worlds as a gaming machine, but for the learners it was also a creator of social worlds where they could chat with friends in the classroom; in this way, they recruited and converted their own digital capabilities into valued functioning.

The second iteration

In a subsequent iteration (described in the output) of the use of the Nintendo DS in this context, several new actors were added to investigate how PictoChat could develop exploratory talk (ET). Analysed from an ANT perspective, several actors were added: the researchers, a popular research method, theories of ET , and a problem to be solved courtesy of the inspection body (Ofsted). The project started the act of translation in ANT, recruiting new actors into a new or reformed network and in doing so establishing its boundary (Callon 1984). This was the ‘problematisation’, when the reason for network formation is defined and outlined and the key actors in the network identified. One set of actors seek to include and recruit others to identify with the problem. As part of this each network member/actor attaches themselves to the problem by defining a goal which does not conflict with others’ goals, and which works collectively towards the problem. Importantly, the goals or motivations may be different, but actors feel they can share a course of action. As Callon notes in his classic ANT text on scallop fishermen, ‘The researchers join forces with the scallops, the fishermen, and their colleagues in order

to attain a certain goal (sustainable scallop fishing). In so doing, they carefully define the identity, the goals or the inclinations of their allies' (Callon 1984, p.8).

In output one, the problem to resolve (improved speaking skills) came from an Ofsted inspection 'in some lessons, speaking skills are developed well, but in others, opportunities are missed for the pupils to develop arguments or express opinions' (Ofsted, 2007, p.6). This was also a key finding of the Rose review of primary education (2009), which advocated that spoken communication should be developed and ICT used extensively (output 1, p.77). The Ofsted report legitimised the project because school managers, teachers and learners, situated within the neoliberal paradigm, are obliged to respond to improving 'standards and performance', or what Clarke 2018 calls 'educational governance matters'. Pictochat provided a way to practise talking through using technology and the presence of university researchers initiated the project, rather like Callon's scallop scientists. The researchers acted as intermediaries, and in retrospect we had a fixed idea of what we wanted to discover, which was to see if we could use the students' digital habits of console awareness, game playing and digital chat to improve learning, and in particular ET, with a mobile device. To this end, previous work on ET informed the research design (Mercer, Dawes, Wegerif & Sams 2004; Mercer & Sams 2006; Wegerif, Littleton, Davis, Mercer, & Rowe 2004). ET added weight to the problem and was a worthy goal for educationalists to strive for because it incorporates criticality, engagement with ideas, and reasoning (Mercer, Wegerif & Dawes 1999) (Output 1, p.77). This made it easy for education colleagues to 'latch' on to the problem because ET also promotes notions of 'worthwhile skills', and purports to provide access to the 'language of power' (Bourdieu 1991) and educational discourse required by learners. I personally

also latched onto this objective as it was very close to the capabilities and functionings outlined in the equalities framework (Burchardt & Vizard 2009, p.51) based on the CA (Sen 1992), which came to characterise my later work. Equally, it fell in with my unreconstructed notion of what education was about (providing access to opportunity, improving life chances, seeing learners as, if not in deficit, then in need of development). I was lining up the dots and drawing lines between them. A plus B equals C.

Further refinement of the goal added more purpose and weight, consolidating the position of the Nintendo within the project. Although as researchers we recognised that much online chat is social, we thought we could structure and repurpose this social activity to make the Nintendo become an intermediary for developing ET. In this sense, the tool was bent to our purpose (Law 1992, p.6), moving it from the 'personal to the impersonal' (Ingold 2000). The chat software was also recruited by the researchers, who defined electronic, digital chat as more worthy than the usual aural/oral version. 'Although much "digital" chat is for social purposes (and as such shares many of the characteristics of speech), it is less perishable and more persistent' (Output 1, p.78).

This justification refined the educational objective and validated the continued inclusion of the Nintendo. Conversely, the Nintendo console's objective was to continue making chat rooms available and could not care whether chat was perishable or not. We also recruited other powerful evidence on why our project was a good idea from second language acquisition researcher Krashen (1983) and Bourdieu's notions on language and symbolic power (1991) (Output 1, p.79). Both

were used to justify using the Nintendo to develop ET, by providing access to standard forms of language using technology in the children's domain. Finally, we recruited a schoolteacher by making them part of an action research project (Attewell, Savill-Smith & Douch 2009; Cohen & Manion 1995), which legitimised their participation in what was a de facto experiment on behalf of the university (Output 1, p.77).

Law (1992) calls this type of assemblage heterogenous engineering. Actants that may have other networks within them, such as the idea of ET or language and symbolic power, as the sum of a wider network of writings and experiments, can be brought into a network to act on behalf of the identified goal. This **punctualisation** (see above) is an interesting process regarding power relationships; as Law notes (1992, p.6), 'How is the work of all the networks that make up the punctualised actor borrowed, bent, displaced, distorted, rebuilt, reshaped, stolen, profited from and/or misrepresented to generate the effects of agency, organisation and power? How are the resistances overcome?' The use of 'action research' encouraged the teachers involved to participate, and to perceive themselves as 'junior researchers' in the network. Callon (1984) calls this the **interessment** stage. Much of the discourse and the ability to use the notion of ET and functional English came from my previous knowledge of McEldowney's *Functional Grammar in Context* (1982), supplemented by expertise from the other university researcher. On this basis, we crafted the following statement for the research goal:

> The DS lesson study, if carefully constructed, would allow learners to build confidence in using the target language (exploratory talk) using a communicative digital medium that they knew well, that allowed them to

> produce when they were ready, and that supplied prompt phrases that could reinforce their acquisition of important underdeveloped spoken language forms for use in education (Output 1 p.79).

I note now both a certainty of purpose and lack of criticality in the project, but this may have been a necessary part (clarity of purpose) of **enrolment**, which is how the actors' presence in the network is consolidated and how they are persuaded to assume roles within the project. Following from this, **mobilisation** occurs, when a second set of actors engage with the problem. Callon (1984, p.6) points out that during this step it is important to consider 'Who speaks in the name of whom? Who represents whom?' At this point, questions of power and structure arise in the network, but at the time these were not considered because the human actors were all within their assigned roles; however, by our various recruitments, we made ourselves more powerful by adding actors (and their networks) in pursuit of the goal. For example, we included: a problem-based pedagogical approach; observations of children's talk; a digital habits survey; a phrase checklist for observing learners; and, two different 'Research Lesson Studies' (RLS) (Bennett et al. 2009).[1]

These later additions act as punctualised black boxes and intermediaries aligned to the pursuit of the problem/goal. Our research questions (RQs) (Output 1, p.80) could also be considered actors created for the purposes of enrolment and mobilisation. These questions had the effect of redefining the study goals for participants, to prevent 'acting back'. Acting back is defined in ANT as the moments when actors disconnect themselves or disrupt the network, so that their presence is precarious as the network is formed. The RQs may also have led to the 'convergence' of actors

[1] The RLS method is outlined in output one (p.80), but is essentially two or more teachers, one of whom conducts a lesson whilst the other observes selected (case) students to see what effects the lesson has.

around the problem and the construction of prescribed solutions and paths to follow (Fox 2000). Law notes that these constructions of the social are:

> at the core of the actor-network approach: a concern with how actors and organisations mobilise, juxtapose and hold together the bits and pieces out of which they are composed; how they are sometimes able to prevent those bits and pieces from following their own inclinations and making off; and how they manage, as a result, to conceal for a time the process of translation itself and so turn a network from a heterogeneous set of bits and pieces each with its own inclinations, into something that passes as a punctualised actor (Law 1992, p.6).

As such, the research project became an entity, a punctualised network become actor in and of itself within a wider scheme of actors —a contribution to the university research activity, the faculty's strategy, and the researchers' career aspirations. This retrospective also notes that the learners are not 'present' in the text; they are not actively recruited as actors or actants, even though they are central to the purpose/problem. ANT and its focus on the heterogeneity of actants and actors highlights the relationships of power that are evident and learners are conceptualised as 'the studied' or passive participants whose participation is taken for granted. In retrospect, this highlights a particular position on my part as a researcher and I wonder still about how easily others speak for others and individuals are homogenised into groupings, even in current projects. The lack of inclusion of participants' voices is interesting in that it was also was not considered in research design or within the research questions. In re-reading the text; the ideas (texts), the Nintendo, the researchers and the teachers all seem important, but the learners

seem to be considered as intermediaries, who will ‘do as they are bid’. There are 52 mentions of learners in the study and none use active verbs. The instances of learners reported as actors are remarkably few: ‘Groups didn’t tolerate “messing about” (going social) on the DS and declined to use them for just chatting. They also commented that the best thing to do was type messages rather than handwrite for the sake of clarity’ (Output 1, p.87). In contrast, the portrayal of the DS made it seem quite active in the study (p.87 ff), as these extracts show:

> DS was instrumental in developing literacy and summarising discussions.
>
> The DS kept them focused and on task.
>
> The DS was instrumental in developing literacy and summarizing discussions. (p.87).

This reflected, I think, my position of asymmetrically favouring technology. The DS is afforded agency, and this was what I wanted to happen; I wanted technology to ‘help’ with the educational project, to be powerful enough to intervene and I believe I constructed it as such. At the time (*see* Becta 2009), there was a supposition that learning with digital technology would supercharge all the outcomes for any educational project. There was no end to what ‘educational’ technology could be expected to do and, whilst Becta’s claims about the use of technology in education were usually balanced alongside required changes in pedagogy or curricula, the emphasis was on the ability of technology to be instrumental in the change**.**

I was personally situated in a halfway house between using technology to improve the lot of teachers and learners but not as the ubiquitous panacea that Becta seemed to propose. My approach at the time was, however, symptomatic of a binary reductionism which ANT counters, as Law (1992) notes,

> The reductionist versions tell that either machines or human relations are determinate in the last instance: that one drives the other. However, though these reductionisms are different, they have two things in common. First, they divide the human and the technical into two separate heaps. And second, they assume that one drives the other (Law 1992, p.3).

ANT clearly disavows this determinism, and indeed other actants in the study evidence a more integrated arrangement between humans and technologies. The digital habits survey, for example, looked at various human/digital interactions. The survey was 'punctualised' but then used to unpack another black box of the learners' domestic digital technology use, unveiling an array of actors that might also support the project. For example, Output 1 (p.80) tells us 'Much of learners [out of school]digital activity, […] is hidden from both parents and teachers. In terms of this specific study the survey results clearly supported the use of the chat facility.'

Thus, the ability to use software and devices that afforded digital chat added weight to their use in the project. The survey (as an actor) unpacked and repackaged digital habits and these were selectively chosen depending on need to strengthen the AN. Figure 10 shows the expanded network after **mobilisation** occurred

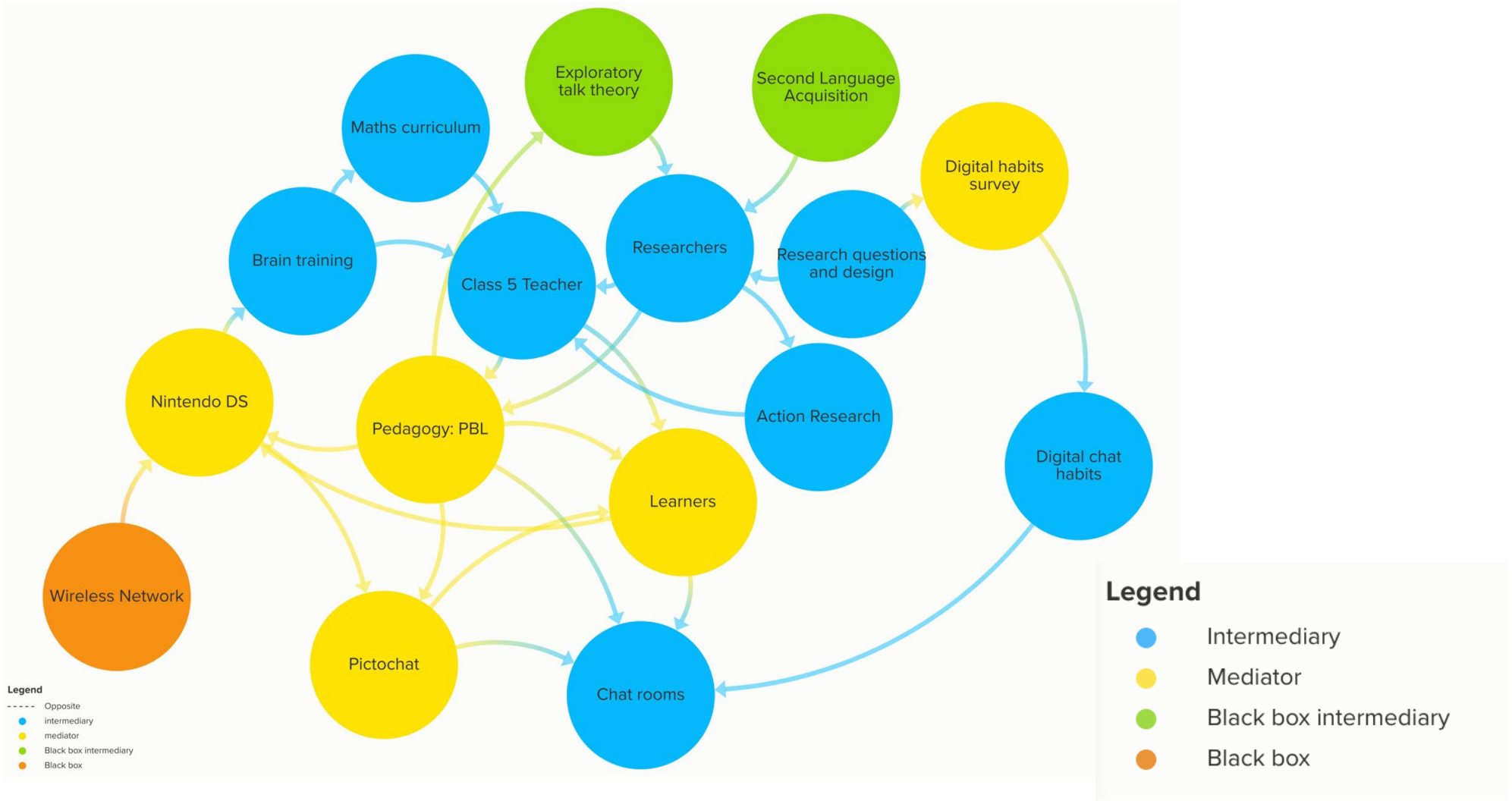

Figure 10. An expanded AN for Output 1

An analysis of the newly recruited elements highlights their role in the translation and status as mediators or intermediaries (Table 1). Mediators may create various outcomes but intermediaries transmit what they are designed to do.

Table 1. The role of newly recruited elements

Actor	Status	Used in stage
Researchers	Intermediaries: transmitters and keepers of the research plan and design	All stages
Research questions and design	Intermediary: sets the framework within which certain actors perform	Enrolment and mobilisation
Digital habits survey	Mediator: Unpacks learner digital habits and then repackages digital chat habits as an actor	Mobilisation
Digital chat habits	Intermediary: the habit allows/legitimises digital chat to be used in the project and supports the DS and PictoChat	Mobilisation
Exploratory talk, action research, second language acquisition theories	Intermediaries: Used to mobilise support for the network and influence other actors. Essentially black boxes used for transmission/ status of knowledge and recruited to support other actors. Legitimises research and consolidates power of researchers	All stages
Pedagogical mechanism: Problem-based learning	Mediator: Although the pedagogical device and framework was predesigned it created unplanned for outcomes and affected a large range of other actors in the network	Mobilisation

The pedagogic mechanism was a highly structured PBL activity which was about planning a space flight using the DS as a communicator: ‘The children worked in four specific teams, flight crew training, life support, guidance, and surveying and engineering, and could only communicate with each other using the PictoChat on the DS’ (Output 1, p.84).

Contrary to expectation, most of the exploratory talk was face to face within the teams, and it was the construct of the problem space that caused this (Output 1, p.85). The PBL scenario produced ET, the DS became a communicator and an intermediary, and the chat room was a chat room (intermediary). The pedagogic mechanism mediated the activity by transforming the other elements/actors (Latour, 2005 op cit.). The project’s initial focus was using the DS to facilitate ET, and although a teacher inhabited the chat to promote this, it did not happen. The pedagogic design did not perform as expected and influenced other actors to assume alternative roles and actions together. The PBL and the space simulation created its own AN by recruiting the children and the DS into roles. This release of agency and transformation through the pedagogical element was interesting. As Law (1992, p.4) notes, agency is always a product of heterogenous entities combining and acting together, ‘Hence the term, actor-network — an actor is also, always, a network.’ It follows that technology use in any educational intervention, might require a role or a place in the AN and, while a technology object can assume different roles, the particular affordance of a technology is selected by the other network actors. It is the introduction, however, of the actor (in this case the PBL pedagogy/mechanism) that invites the use of a particular technological affordance by other actors. The DS

was not used as expected and the pedagogic actor caused the change, contrary to the research design. I also recognise here my presence in the network as a researcher and my interest in integrating technology into learning and the benefits I perceived in using learners' digital habits for inclusion and participation. As a result, I saw more agency in the technology than in the other actors in the network and partially recognised this in my conclusions:

'It was also somewhat assumed […] that the intervention with the DS would somehow naturally lead to changes in learners' practice. This belief in the affordances of an item of technology for learning purposes is misplaced' (Output 1, p.88).

The other actors were seen as a means to an end (black boxed) in the project because the intervention was DS-based. There was also an assemblage of power in the network where some actors spoke for, or even made invisible, others (Callon 1984; Law 1992). Equally, I did not understand that affordance (where the object is fluid) is perceived and chosen by the user, not designed into a project so that the desired affordance is chosen. I wonder now if this was an assumption based on the asymmetry of analysis and the position of power we constructed as researchers, a sort of naive arrogance. In this sense, the combination of PBL —in the situated action of the context (Suchman 1985) and the fluidity of role (Laet & Mol 2000) of the DS —created a degree of participant choice and control (AF). According to Ingold (2000), people use tools for what they can do and the more central they are to that process, the more likely they are to develop skills in their use. Digital tools are no exception and, if they are personal or familiar, then users are more likely to develop skills in their use beyond their regularly used personal functions. Both human and

non-human actors combine to achieve goals when using tools, as distinct from machine-led processes which may at times exert control or 'shape social relationships' with humans and vice versa (Law 1992). Ingold (2000) suggests that tools are not intended to control but to reveal new possibilities and to create. Consequently, any actant/actor that affords other actors AF within an AN provides the opportunity to develop capabilities and may create the circumstances for these to be converted into valued functioning. When the PictoChat function was chosen by learners to create something different within their lessons by using their digital habits in school, did this then lead to the recruitment of PBL and further unexpected outputs and development of capabilities? Are actants/actors that 'mediate' as in Latour's definition above potentially more likely to afford choice and agency in other actors than those acting as intermediaries or that demand prescription? This will be explored further in relation to subsequent outputs.

The output also details what it calls 'moderators' to the sustainability of the network. In ANT, this is where the network starts to break down as actors 'act back' (Fox 2000). It should also be noted that I am 'acting back' against my former self as a researcher from a later privileged position and as a result judging more harshly my endeavours. In the DS project, 'acting back' was highlighted as: finding it difficult to integrate technology (DS) into lessons; realising PBL involved extra work to develop simulations; and, not understanding of the concept of ET. None of these 'reasons' for stopping were counteracted and here, again, ANT gives insights into why this might be so, with implications for the sustainability of the intervention. The understanding of talk theories was received as a package (intermediary) and not understood by the teachers. This highlighted a need for training or exploration for the concept of ET to

act differently and possibly as a mediator within the network. Equally, the DS was not perceived as a crucial actor within the project by the teachers who suggested that more appropriate ‘work like’ technology, such as laptop computers and Skype be used (perhaps in hindsight these devices afforded more control). This would have the effect of disengaging the DS, PictoChat and the social chat habit from the network.

In output one it is clear that the learners were presented as mostly passive. In the problematisation and mobilisation stages, they were made voiceless and absent; the learners were not considered other than by their proxies, the teachers. They were just expected to participate and assume their role, and were not overtly recruited or consulted. Callon and Law (2004) deem this to be an absent presence, where, although present in the network, the learners are absent in action and participation in the text (which probably reflects the distribution of power in schools quite accurately but does not excuse my retrospective self from missing this in subsequent projects). ANT is about looking for effects and when the learners acted with other mediating actors they possessed agency and were creative and did things that were unexpected by the other actors. Indeed, Law (2004, p.83) proposes that, ‘What is being made present always depends on what is also being made absent,’ and this notion is brought to the fore in this retrospective of my outputs and research, and is a consistent element within ANT. There is another absent actor in Figure 10, and by its absence its presence becomes more obvious. Referred to ten times in the text, it is in the background, doing what it does, delivering content and skills and constraining the other actors through its role as supra intermediary. ‘The curriculum’, an ever present in any educational context is often presented as a ‘black box’ that is never

really unpacked and ‘transports meaning or force without transformation’ (Latour 2005). Thus, embedding ICT is legitimised in output one (p.77) as,

> Embedding ICT throughout the primary curriculum and giving it greater prominence within the core of ‘Essentials for Learning and Life’ will provide children with more opportunities to harness the potential of technology to enhance learning (Rose, 2009, p.21).

and,

> Having located the research within a real curriculum development need for the school,
>
> as researchers we used the reference to curriculum to recruit others to our purpose, and as such recognise its role and omniscience in the school. (Output 1, p.87).

Indeed ‘the curriculum’ was also used as a reason for actors resisting the ‘new network’ through ‘acting back’ where teachers had concerns about: ‘perceived and actual constraints on time […] to spend on such activities **within an already crowded curriculum offer that is objective-based and target-driven**’ (Output 1, p.89). This highlights the need to consider all actors in a network and uncover some that may not be ‘visible’ if reform or transformation is to be sustainable. The ‘curriculum’ was clearly not fully aligned with the project and certainly not under the control of the teachers, except for when it was invoked as an ally for not doing something. The curriculum appears to be something that is black boxed and not changeable or adaptable or fluid in any sense or, at least, it was constructed that way in this instance. The curriculum, as a black box, is difficult to define and unpacking what it means to different people, its use in different contexts and its

constituent actors is a task that ANT analysis could be used for. ANT allows a different perspective on the construction and enactment of educational interventions, which, when perceived as projects, have a planned structure. Indeed, ‘plans are prerequisite to and prescribe action at whatever level of detail one might imagine’ (Suchman 1985, p.21), where input **a** leads to activity **b** leads to output **c**. Even where the privilege of researchers is recognised and methodologies chosen that allow for outcomes to be realised from encounters rather than being pre-determined by the use of certain tools, there is a sense of reducing and refining scope to a few manageable actors to consider certain aspects of practice and not others. Although this may not be true of all approaches, within any project/intervention there is a beginning, middle and end to most, and while outcomes at the time may be tangible and meaningful there is also an element of closure on completion of impacts that may be less tangible. As Latour (2005, p.37) says, ‘if a dancer stops dancing, the show is finished, no inertia will carry us forward.’

This somewhat quasi planned approach is a vision of actants (research instruments included) as intermediaries that ‘transport meaning or force without transformation: defining its inputs is enough to define its outputs’ (Latour 2005). By this, I mean that by our choices and scope, and by selecting methodologies that act as intermediaries, I, as a researcher, know what the actants will do. As researchers, there is a dilemma in realising the importance we place on certain actors rather than the whole network, and this perhaps foreshadows our results through our design. ANT gives an opportunity (not necessarily always taken) to map all possible actors and trace the interplay between them, and has the potential to focus on the mediators and the actors that transform, as well as those that block and constrain, to

allow the development of networks and acts of transformation in education more effectively. Of course, there is an issue in how the potentially 'ever expanding' network of actors is cut (Strathern 1996), because that which is left out or discounted must also be recognised, accounted for and justified in line with the goal or purpose. However, once this has been decided by focusing on those that act, the focus for intervention can shift to other actors in a bid to transform the network itself in either direction, from intermediary to mediator or vice versa. This is also related to stability in an actor network , and how the network is established and maintained, and it may be that an objective of establishing an actor network is to create a new orthodoxy, potentially making mediators into intermediaries. For example, rather than being a force for change, PBL may well become the way things are done. Thus, perhaps both intermediaries and mediators can be agentic, but in assembling a network designed to transform a current state, the mediators should be examined more closely to see what they can do differently or what new practices they might induce.

I made an assertion in the final paragraph of output one to avoid being charged with technological determinism, as the output focused on an item of digital technology rather than the teachers and learners. I state that 'it is important to remember that there is no 'agency' within technology' (Output 1, p.90). This is an opposition that ANT helps to dissolve; in Law's words (1992, p.7), ANT 'asks us to treat different materials —people, machines, "ideas" and all the rest —as interactional effects rather than primitive causes'. This theme of people and technology evolves through the papers as I move towards a different position. Had I encountered ANT at the time of output one, I might have rejected the asymmetry that favoured one approach over another. On further reflection, at the time I was steeped in managerialist pragmatism

derived from my funded project work and materials development, where all I had to do was ‘change this to affect this’. My modus operandi, as output one suggests, was: ‘Rather than adapting technology to fit the patterns of pedagogy within the classroom, we should consider the ways in which learners engage in digital environments and adapt our pedagogies to exploit this engagement’ (Output 1, p.90). At the time, this depicted both my limited view of the ontological scope of technology, and, while not quite being a diminution of the importance of teachers and their relationship with learners, perhaps a lack of focus on this relationship whilst championing learners’ capabilities. I was afflicted by an asymmetrical view. In art, to draw a chair we focus on the lines of the chair itself when often it is better to focus on the spaces to realise the chair. ANT affords a view of both the chair and the spaces. At the time of output one, I did not perhaps read enough into Fisher’s remark that is the final sentence. ‘Fisher (2006 p.301) notes, “Digital technologies provide the tools or mediational means to be used by teachers and learners. The key to this approach is that neither the teachers nor the tools may be understood in isolation”’ (Output 1,p.91.)

The analysis of output 2 looks further at the process of translation, develops the idea of agentic mechanisms and pedagogies, and also considers how a project’s learning purpose is aligned to various actor goals. Introducing the idea of digital tools being aligned with making, rather than following industrial processes, means that it also the diving force of purpose in educational interventions. It also considers how mechanisms or mediators become ‘fluid’ by presenting options to solve a problem.

Output 2. A closer look at the process of translation in ANT — how an actor network is created

Output 2. Royle, K. & Hadfield, M. (2012) ‘From ‘Posh Pen and Pad’ to participatory pedagogies: One story of a netbook implementation project with 108 Pupils in Two Primary Schools,’ *International Journal of Mobile and Blended Learning*, 4(1), pp.1-17.

Translating the problem into an actor network

The title of the output, 'From Posh Pen and Pad to Participatory Pedagogies' indicates my direction of travel as a researcher and most of output two is a story of how the ‘problem’ (of educational technology integration) is translated into an actor network. The retrospective here concerns tracing how a network was formed, and my own part in these proceedings regarding reasons for exclusions and how particular boundaries were drawn. This meta awareness was not present at the time, and the project seemed to evolve as it progressed. For example, as experts and researchers, I and my colleague came to the project armed with our models and frameworks (Balmer et al. 2010; Hadfield et al. 2009), to create or engineer consent for the project amongst the stakeholders and participants. The goal was to ‘improve’ learning and teaching, or to modify learning and teaching into a new form focused on independent learning, participation and creativity. We used these goals, which implied that the teaching and learning was in deficit, being neither learner-led (independent) and creative nor overly participative, to create a problem and mobilise others to a cause. This construct was developed through meetings with headteachers and teachers and we created several ‘obligatory passage points’ (Callon 1984, see Analysing using the ANT toolkit), where actors must latch onto the

problem by defining solutions that make them want to form alliances to achieve their distinct goals collectively. As researchers, our personal goals contributed to the development and assembly of the actor network , and in retrospect I align mine as an interest in authentic, student-centred practice to effect change, but I cannot speak for my co-researcher in this regard and can only assume that he had other goals. Important here and for future conclusions is the purpose of the project, because it defines the reasons for our endeavours and their potential success. As a researcher, in output two I was acting back (as in output 7, p.264) against 'the assumption that technology enhances learning in an unreconstructed way,' for sitting behind this is the policy black box (Becta 2009) of wanting to 'harness' technology to improve existing educational processes and standards.

In the school, at the time, technology use was advocated by the headteachers to see if it could improve outcomes for children, and it was certainly a goal for them as they had purchased 'netbooks'. The 'problem of integrating technology into learning' allowed other actors to be recruited on the promise of the benefits it could bring to all concerned (Becta 2009, p.28). To some extent, the policy agenda of perpetually increasing standards for schools and teachers, described by Clarke (2018), helped with this recruitment because teachers did not want to be seen as being left behind in terms of abilities and skills. Output two noted that whilst school leaders and managers had bought into this vision of technology their teachers had not. The project was able to recruit leaders to the project because, although they had probably invested in the technology to upgrade children's access to technology (Negraponte 2007), they had yet to see the equipment being used other than by the children for social purposes outside of school. The school leaders brought their own

ontology of the benefits of technology and this was their motivation: ‘Leaders had had the time to evaluate the particular technology at length and at education shows before deciding on the purchase. Thus, whilst leaders had seen the advantage that a particular piece of equipment could provide, they had not really considered the environment into which it would be placed’ (Output 2, p.12).

However, instigating ‘curriculum flexibility’ and ‘improving’ teachers’ skills and confidence, recruited from Balmer’s model (2010) (output 2, p.4), allowed the project to recruit teachers and managers alike. As researchers, we listened to teachers’ needs and concerns and bent them to our research purpose using our models to persuade them. Similar elements to output one were constructed: a curriculum initiative, action research to legitimise our activity, and an overarching purpose of ‘developing independent learning’, in the belief that the technology would be used in a ‘better’ way. The ‘creative curriculum’ (CC) documented in the Rose Review (2009) supported this initiative and added weight to our problematisation by requiring ‘a well-planned and vibrant curriculum that enhanced independent learning, engagement with practical activities and the development of empathy through the opportunity of working with others’ (Kirk 2012, p.5). The fact that teachers knew they had to respond to the CC but had little time or opportunity to consider it aided the project as initially they felt that the netbooks were just a burden.

The first project phase considered how teachers were currently using netbooks. The process of translation was started by identifying actors, sparking interest in a ‘problem’ and then mobilising others. To help with this, a deficit model of technology

use was created by the headteachers, the researchers, and the teachers themselves, as follows:

> The first key issue was the learning status of the netbooks. In initial discussions with the teachers, it became clear that they had had insufficient time and direction to consider the learning potential of the netbook and tended therefore to treat them in a way which we discussed with them as a 'posh pen and pad' (Output 2, p.6).

On reflection it would seem that the netbooks had been integrated (as digital replacements for pens and pads) into the existing teaching paradigm but, clearly, all those involved were dissatisfied with this. Armed with the creative curriculum, some taxonomies of independent learning (output 2, p.7), the support of leaders to release teachers to consider alternatives, the action research incentive, and the netbooks themselves, we set about aligning the netbooks to our purpose. Each actor in output two had different motivations for working on the project and attaching to the problem, similar to the situation described by Callon (1984, op cit.). Indeed, Law suggests there is a hint of Machiavellian politics at work in securing the actors in a network and avoiding them acting back: 'Translation is more effective if it anticipates the responses and reactions of the materials to be translated' (1992, p.6). In this case each actor's goals were aligned to the researchers' intention of introducing independent learning, participation and creativity. Whilst this was not completely obvious at the time, subsequent interviews with participants meant these goals could be discerned in their responses. The affordances of the netbook were recruited to a more expansive role within the project. Figure 11 below shows how the different goals combined to form the AN and align with the overarching purpose.

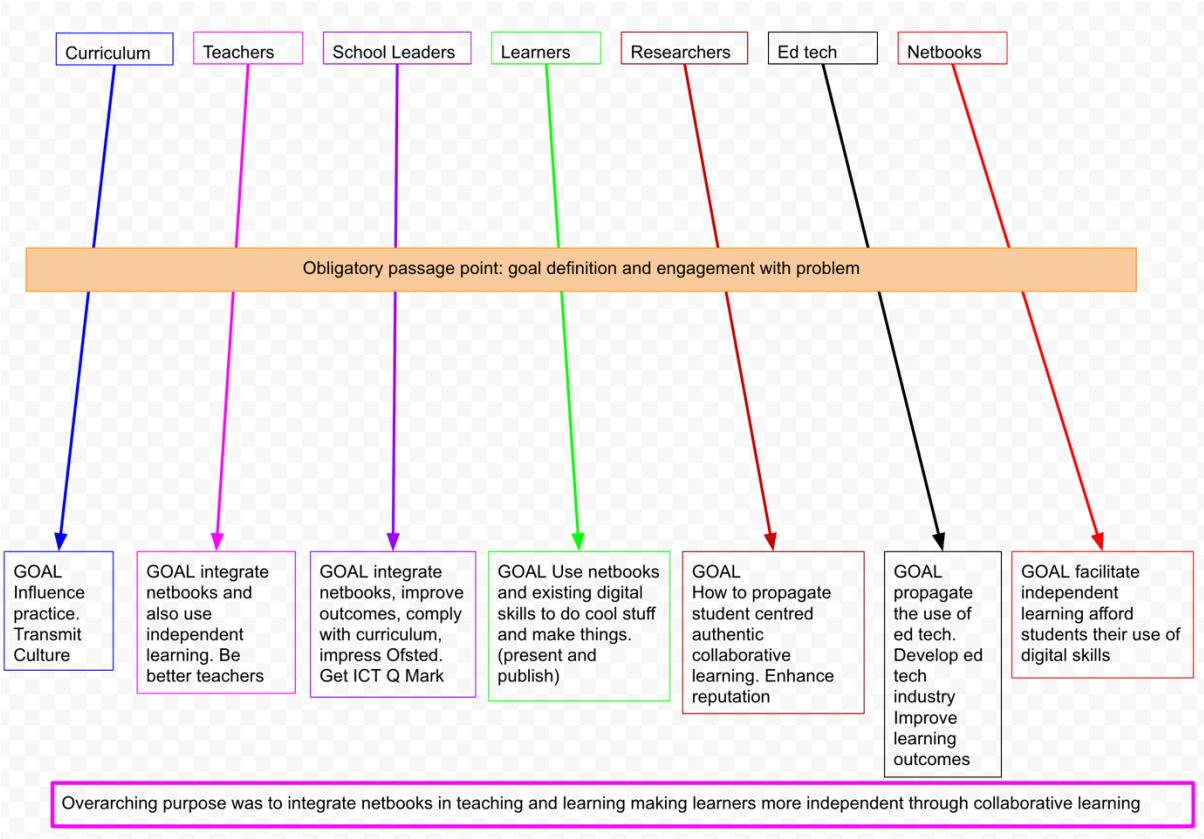

Figure 11. Goals compliment the researchers' overarching purpose Adapted source: Callon (1984)

The multiple goals are initially in response to the purchase of the netbooks and promises about their utility. This created an integration problem, or a type of actant switching (op cit.), so that the affordances of the netbook could be used and integrated into practice. Interestingly, the intervention (arguably technology-led) was not designed with a particular long-term transformational outcome in mind. Rather, it was an experiment without a clear design and on reflection this adds to the notion of iterative learning design in situ, which in turn aligns with the notion of action research. Not all teachers wanted to use the netbooks and many of them acted back, probably because they would need to change the way they taught: 'the project required a great deal of external support and high levels of persistence and

motivation by the teachers involved. […] There was anecdotal evidence that other teachers wanted to avoid taking over classes using netbooks' (Output 2, p.12).

The AN for output two is shown in Figure 12.

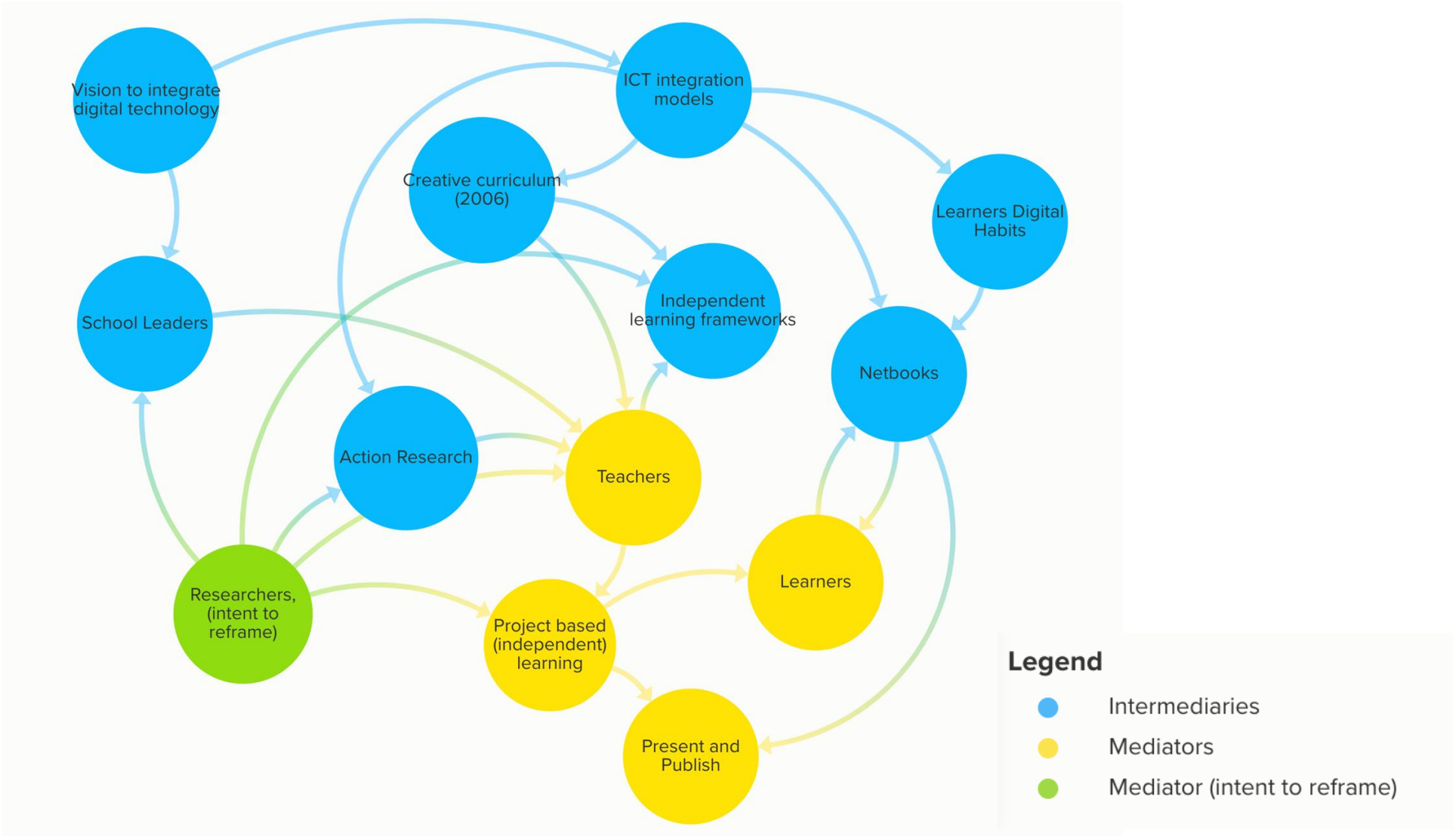

Figure 12. Actor Network, with intermediaries in blue and mediators in yellow

Identifying agentic mechanisms that develop capabilities and freedoms

In output two, the teacher/mediators and learners used Project Based Learning (PrBL)and an assessment mode of ‘present and publish’ for the project. The researchers (intent to reframe the use of netbooks for learning —green in Fig. 12) instigated the problem and recruited powerful actors to solve it, and although each had different goals, they were able to attach themselves to the problem around ‘independent learning’. This is linked to the personalisation agenda (Becta 2009), supported by the provision of personal technology:

> To achieve the best educational outcomes, teaching and learning resources should be tailored to the needs of each learner. Technology can help bring this about. It can give learners the choice to learn at a pace and time to suit their needs. It can improve teaching approaches and extend the choice of study modes available to learners (Becta 2009, p.28).

How ‘independent learning’ was to be achieved was quite ‘fluid’ and initially undefined. The subsequent co-constructed, PrBL model allowed a role for the netbooks to do what they were capable of, by opening up their range of affordances.

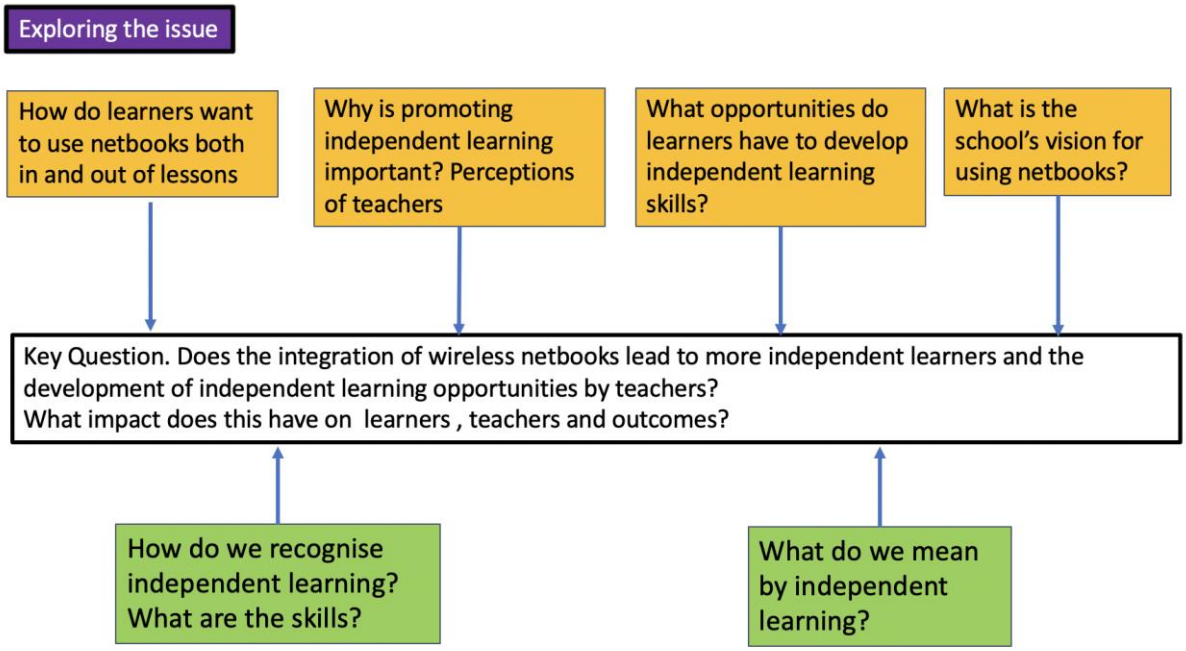

Figure 13. Project conceptualisation created by teachers as part of the 'mobilisation' diagram. Orange boxes: internal source, green: external source

The original project concept above has the netbooks as the 'lead' actor (key change agent), illustrating the asymmetrical approach to the project. In retrospect, ANT analysis reveals a wider combination of actors/actants that influence transformation in practice. Independent learning is in fact the main item in Figure 13, and this became the overarching objective of the project. The netbooks were recruited and were needed for the project to happen but did not **have a direct role** at this point. Netbook use was supported by the learners' digital habits, required for learning purposes, and their different domestic/social digital capabilities needed to be recruited to the school learning space. Arguably, the mechanism/actant of PrBL, structured and developed by the teachers, provided the space for actors and actants to combine.

Agency and capability released

Impact is an important component of any educational intervention and it is interesting to note any effects on teachers' and learners' capabilities and AF. How did this particular network transform teaching and learning from a restrictively functional approach to a more expansive one that transferred and released agency to participants? The basic premise of the new approach was that learning was teacher-instigated but learner-led:

> Teachers planned new pieces of work in which pupils would be given far more freedom in deciding how they might present their work. This involved pupils working in teams to present work but being allowed to choose which topic they would research within a broad theme (Output 2, p.8).

Although the netbooks refused to join to the school's learning platform or load correctly, because learners had to use the netbooks for their own projects, they started to fix them themselves. This enabled learners to use skills developed within their social digital use to create solutions within school that the teachers could not. They became 'technicians' and 'fixed' the netbooks at certain times during the day. This is a clear example of capability being converted into valued functioning, but is also connected to self-organisation (Brandt 2016; Ward 1966). The learners had the clear purpose of having functioning netbooks to present work in various ways, an imperative in that there was limited time to achieve their work, and rules on how to achieve the goal. This is one example among many where teachers relinquished some control, legitimised and actioned by the pedagogical reconceptualisation of promoting independence in PBL:

> I gave the children independence in the afternoons. I gave them topics and methods of presenting and a planning sheet and they planned what they

> wanted to do. I'm much more confident of the children using the netbooks, they have much more independence and freedom. They make decisions for themselves, which they weren't doing before (Output 2, p.11).

The young people were exercising choice and using and developing skills which they previously would not have, making learning and teaching a more equitable project than the previously narrower focus on proficiency in English and maths:

> Children have been finding things out for themselves and teaching others. X came in one day and said, 'I've done it', I've done it.' So, she led the netbook session and showed the others how to do it. We filmed this on the flip camera, and she did the teaching. She's not necessarily one of the more able children in terms of literacy or maths or ICT so it was good that she was able to show what she could do (Output 2, p.11).

In this case, a wider choice of assessment outputs gave this learner the opportunity to choose and also convert innate skills into a valued functioning. She was included, where previously she might have been excluded. Learners also recognised their own independence, bringing wider and deeper knowledge into the regular curriculum:

> It's made our learning more independent. I prefer to find out for myself because if Miss tells you things you will all know the same thing but if you all look you will all find different things so it's better (pupil in School A) (Output 2, p.12).

The act of making and choosing what and how to do something individually or collaboratively (a type of situated action) attaches and releases agency in the actors within the process. As in output seven, the pedagogic actor combines with others to affect both mode of assessment and curriculum. This act of collaborative making releases AF, develops skills and converts capabilities to valued functionings.

Teachers too are transformed by this pedagogic shift to student-led and planned learning:

> I just didn't think I could step back as much before. It's about not being so much of a teacher and standing at the front it's about letting them explore and do things (class teacher 1, School A) (Output 2, p.10).

Other teachers scaffolded the process by providing planning tools, for use in the spaces that had opened for learners, to help learners structure situated action (Suchman, 1985). The authentic nature of presenting and publishing their own work for review, which was the goal of the pedagogic act, also made learners focus more closely on the quality of their own outputs.

One question arising from this is how this release of agency occurs. Bandura (2001) notes that human agency requires control over what is done and how it is done. Planning for action, acting and reflecting on past actions, as well as creating meaningful artefacts, is a key part of constructing control over events. Working alongside this is SO, which some pedagogic frames promote through opening a space in which it can occur through a loose scaffold of rules, a purpose, and an imperative for participating and creating solutions in response to a problem or project. It would seem that project- and problem-based pedagogies possess these attributes when they are combined as actors in networks that recruit personal digital technologies.

Acting back against an orthodox approach

The process of **punctualisation** makes assemblages manageable and understandable and able to act as one. Thus, within curricula, pedagogy and

assessment educators accept what is customary and rarely question how they came to be or their control over how things are done. Teachers increasingly, are guardians of the extant and as such are intermediaries for established ways of doing things to meet the standards required of them. Clarke (2018) suggests that teachers are 'given personalised "responsibility" for their students' test scores and (have) relentless pressures to improve results as school leaders relentlessly enforce the ideology of standards' (Clarke 2018, p.10). Indeed, teachers are expected to perform, are increasingly risk averse, and unlikely to experiment by themselves in a climate where any deviation may be frowned upon. Moreover, it takes a strong counter-argument to break the ties to orthodoxy. In the case of output two, an alternative orthodoxy was created by a combination of technological determinism and the 'creative curriculum' document, which mentioned independent learning and legitimised the assembly and practise of different approaches to learning and teaching.

Personal, wireless connected, digital tools seem to undermine the position of teacher-led learning, where a particular body of knowledge and skills is mediated and delivered to learners who are for the most part passively receptive. Combining learner agency, and so-called digital literacy skills, arguably provides a space in which individuals can develop to their full capacities or capability (Williams 1965; Robeyns 2006). The Next Generation User Skills (NGUS) model (Kay et al. 2008) and the Digital Competence Framework 2.0 EU (Vuorikari et al. 2016) both classify digital skills and competencies into broad areas, such as enquiry, participation, and production. Whilst it can be argued that these skills underpin the needs of industry, they also outline participative, collaborative and creative aspects that, when combined with agentic participatory pedagogic approaches such as PBL, become

part of learning. The act of creative production as observed through the ‘present and publish’ assessment in output two led me to think more about the act of making and doing with personal digital tools and their role and interaction with agentic pedagogies.

About making, knowledge and skills (ingold)

In exploring technology, Ingold (2000) proposes a separation of human agency from action that occurs due to mechanisation: ‘With this reduction of skilled making, tekhne, to “purely technical” execution, the performance is no longer seen to issue from the hand and eye of the concrete, experiencing human subject, and acquires a kind of objectivity and independence from human agency’(Ingold 2000, p.296). Ingold makes a further distinction between skills and techniques, where skills are acquired in context by learning and doing, whereas techniques are more explicit and context-independent and can be taught without recourse to doing. He notes that the human subject, both as an agent and repository of experience, has been drawn from the centre to the periphery of the labour process (Fig. 14).

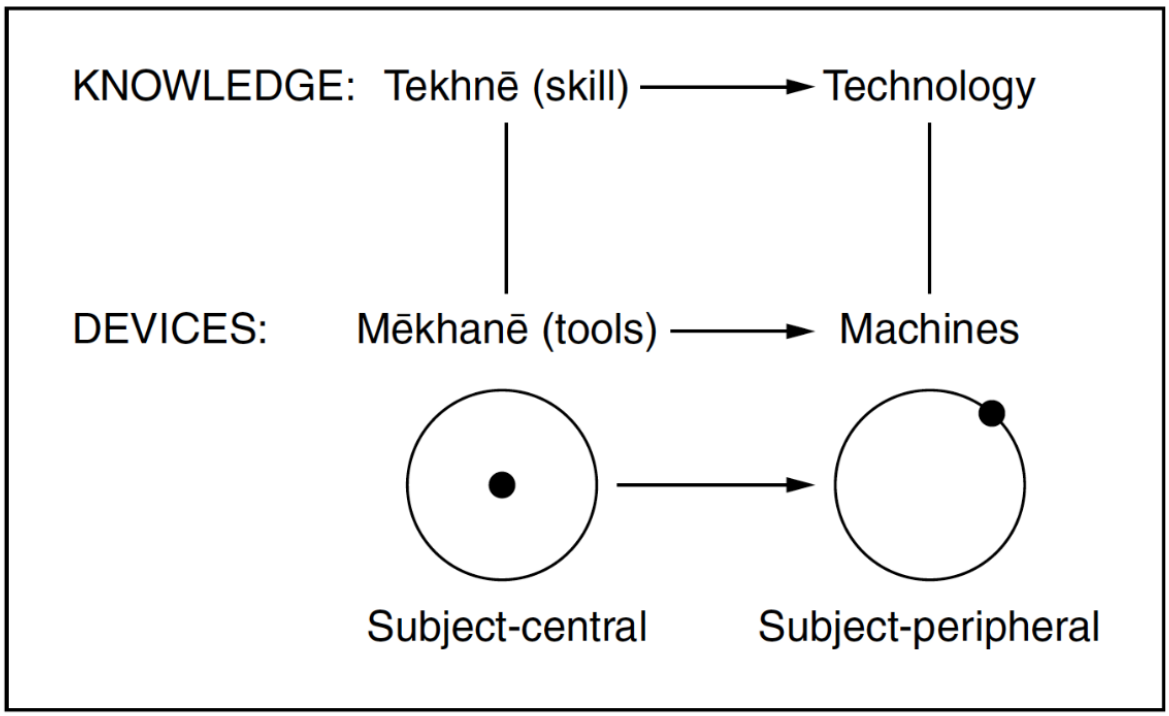

Figure 14. Changes in human interactions in the movement from tool use to machines. Source: Ingold (2000, p.317)

In the field of formal education, we can note that this division pervades to an extent where 'technological knowledge' is championed above the knowing how and doing, removing human agency (in terms of developing skills) from its context. Arguably, pedagogies that require making and producing, even of knowledge, are afforded by the use of digital media and equipment which allow learners to become subject-central rather than being operatives and subject-peripheral in a seemingly industrial process. The curriculum expands to be contextual, personalised and inclusive and pedagogic engagement is about designing, planning and making in context, to address problems or issues whilst drawing on explicit knowledge to augment and inform. In this process, a solution's effectiveness can be its only evaluation. In our conditioning through the machine age and through neoliberal conceptualisations of education, we have become accustomed to an education process that runs in

support of an economy based on endless growth, market expansion, and resource exploitation. As Clarke (2018) notes (quoting McGowan 2016),

> Central to the values and logics of the market-based economy is the fantasy of unlimited growth and 'the possibility of having more than enough of what we desire' as a way of escaping the trauma of scarcity (Clarke 2018, p.11).

Curricula, pedagogies and assessment that currently support this cultural transmission can be reformed to reflect a more cyclical, sustainable economic model (Fullerton 2015). ANT supports analysis of interventions so that alternatives can be examined, and provides a potential mechanism for the design and redesign of education that accounts for context. Law (1992) suggests that 'Actor-network theory analyses and demystifies. It demystifies the power of the powerful' (Law 1992, p.8). If this is the case, it means that we can see how networks are configured and assembled so that changes can be made. Output two at this point gave a glimpse of the possibilities for change in both pedagogy and assessment, but it is perhaps the curriculum, linked to educational purpose, that needs the most attention. The retrospective uncovered some interesting stones by investigating the idea of agentic mechanisms and pedagogies in interventions, discovered the importance of purpose in educational interventions, and showed how heterogeneous engineering is based on notions of symmetry and asymmetry. It also considered how mechanisms or mediators become 'fluid' by presenting options to solve a problem. It also introduced the idea of digital tools being aligned with making rather than following industrial processes, and considered aligning educational purpose with environmental sustainability over notions of continual economic growth. Output three below moves on to discover further examples of absence and presence in research projects, and what is included and excluded, so that in future designs all actors might be

represented at inception. To this end, it considers the process of unpacking ‘large’ entities such as neoliberalism as actors within a network. Capability is also further considered as a means for judging the outcomes and effects of educational projects.

Output 3. What are the elements needed for transformation? From curriculum to practice

Output 3. Royle, K., Stager, S. and Traxler, J. (2014) 'Teacher development with mobiles: Comparative critical factors,' *Prospects*, 44(1), pp.29-42. doi:10.1007/s11125-013-9292-8.

Output 3 suggests a 'curriculum' for teacher education developed through situated practice using a mobile phone technology to record and examine a specific teaching context. As in previous outputs, personal, digital technology is placed asymmetrically as a source of change, disruption and transformation and several other actants are recruited in support of this position. Output three comments on different possibilities for teacher education with mobiles and engages in 'black boxing and punctualising' to recruit actors to support its arguments. It combines several elements that occur across the outputs including digital habits, learner-centred pedagogies, AWP, capability theory and reflective practice. Output three assembles these to argue for 'teacher development with mobiles', but no specific contextualised problem is articulated. Consequently, the actors do not act because they are assembled without a problem that others can support: 'Without purpose, problem or goal —there is no actor network because there is no activity' (Latour 2005, op cit.). However, output three did contribute to a wider debate around the use of mobile devices as a potential 'driver' of development and so, arguably, the construction of the output was purposeful in this regard. Indeed, one can see the output's merit as an immutable mobile (Latour 2005, p.237) which is an assembled form that influences other actors in other networks to support their purposes.

Absence and presence

Output three sets out its orientation to a neoliberal educational agenda by delineating several ‘purposes’ of education. This is at a higher level of granularity than Bernstein’s three message systems of curricula, pedagogy and assessment (1975), and as a result they are made a little absent as output three never clearly locates them within any of the purposes of education. It does suggest a curriculum but does not define it within a particular educational purpose or context, which perhaps reflects its more general position as a synthesis of each author’s views and experience. Law (2003) calls this phenomenon ‘manifest absence’ within an ANT perspective that tends towards empiricism, as a ‘Presence, then, is any kind of in-here enactment. Manifest absence goes with presence. It is one of its correlates since presence is incomplete and depends on absence. To make present is also to make absent’ (Law 2003, p.83).

The paper assumes that education occurs within a neoliberal ontology of educational purpose (made present) and that each of these broader purposes has its associated functions of a curriculum, pedagogy and assessment (all manifestly absent) that are self-perpetuating of their purpose in stable rather than dynamic states. Output three presents five possible educational purposes:

1. as being a preparation for life and for work;
2. as a process of personal development or socialisation, of becoming somehow better people;
3. as acculturation into the dominant cultural group;
4. as a hidden curriculum intended to produce a politically compliant and acquiescent workforce;

5. as an agent for bringing members of marginal communities into the managed settled mainstream (Output 3, p.3).

The paper presents education as a construct that serves the established status quo. Each of the five purposes has a similar goal: that educational achievement of some sort, aligned with either a social good or access to the economy, is something to strive for. The paper, to its credit, also acknowledges that this may just be a western construct and that other cultures may have differing conceptualisations of the purpose of education. However, although this may be true of some societies, the globalisation agenda and the neoliberal promise of growth and improving standards of living holds sway. The paper punctualises western education as a 'black box' (a given) and to a certain extent also locates technology and educational technology as an integral part of the same package, accepting of the 'digital' technologies and methods it employs. Output three (p.4) notes that hitherto the technologies of education have been the institutional VLE or the appropriated complex technologies of the corporate world (office packages/web browsers).

The paper constructs traditional, stable educational institutions that have 'used new technologies to do the work of the old' (McLuhan & Fiore,1967) in newly constituted 'education factories' where teachers are but 'overseers'. Against this construct is placed the disruptor of 'mobility' and the mobile digital device as an actor alongside the human in any context. It is an interesting idea not without validity and my attraction to the premise is clearly situated in the idea of 'acting back' against the received orthodoxy. 'Use of these technologies changes the nature of knowing and knowledge. Using mobiles transforms what people know, what they need to know, when and how they need to know it, who they learn from, and who they teach' (Output 3, p.4).

In output three the existing format of education is challenged by mobile devices which are valorised as change agents and disruptive of ‘existing ideas and assumptions about learning’ (Traxler 2018, p.297). Although at the time I was enthusiastic about the possibilities of mobile learning, in retrospect the ideas seem a little prone to entrapment within existing educational systems but perhaps this is a part of their fluidity.

Disruption and mobile devices

Looking back, the claims made about mobiles are a little technologically determinist and they are privileged with a singular agency within the text. As mentioned previously, ANT does not accept this reductionism arguing that social change or stability is determined neither by objects nor people alone (Law 1992, p.3). With this in mind, the paper makes further claims about the power of mobiles to ‘transform’ society. I am conscious that this was perhaps not the intention of the authors and it is only this ANT analysis that makes it stand out as such: ‘These technologies have a transformative effect on language and discourse, on identity and community, on relationships and social practices, and on economic activity, that is on the nature of assets, artefacts, resources, and commodities and on work practices and work relations (Output 3, p.4).

As a result, whilst the agency and affordances in mobile devices are undeniable, they are a part of human social practice and their contextual networks, and this aspect is black boxed and unexplained, perhaps unintentionally, as part of the paper’s goal. Consequently details of mobiles within assemblages of the social and how they act is not accounted for and as such the claims (without examples) are a

little broad and monolithic. In this case the ‘agency of mobiles’ is a generalised, punctualised construct of the text, which creates a generalised call to action rather than specific evidence of effects in context. The narrative recounts even though there are several purposes of education they are all in service to a pervasive global economy. Within this environment, educational institutions use technology to standardise and control learning for the purposes outlined with teachers becoming overseers in these ‘education factories’. This is strongly counter to an ANT approach as Latour (2005) suggests,

> In ANT, it is not permitted to say: ‘No one mentions it. I have no proof, but I know there is some hidden actor at work here behind the scene.’ This is conspiracy theory, not social theory. The presence of the social has to be demonstrated each time anew; it can never be simply postulated (Latour 2005, p.53).

On reflection, the idea that the output is a punctualisation, an actor made to serve other projects falls into current narratives of ‘disruption’, as developed through recent constructs of the ‘post digital’. Jandrić et al. (2018) consider the idea of digital disruption problematic and constructed to serve a purpose: ‘Whether to remain competitive or to provide better teaching and learning, healthcare, administrative services, or governance, “the digital” is envisioned as a means to improve, innovate or disrupt the existing. […] Digital innovations are] mobilised as rhetorical devices to promote particular “socio-technical imaginaries”’(p.165).

The point here is that technologies do not act alone; they are always entwined with other actors for particular purposes. Paradoxically, while the mobile phone has

undoubtedly played a part in social change (Aker & Mbiti 2010; Asongu & Nwachukwu 2018), as authors we avoid any critique of mobile technology associated with its use, provenance or design. For example, phone companies and the social media giants that scaffold digital social interactions for profit are othered in the paper, and their role remains unexamined. In this regard, Law (2003) defines otherness as follows: ‘absence that is not made manifest, [it] also goes with presence. It [otherness] too is necessary to presence. But it disappears. Perhaps it disappears because it is not interesting while it goes on routinely’ (p.83).

The construction of mobility as a disruptive force for good is, whilst evidenced in some instances, a little unbalanced even for 2013 when I was well aware that Palestinian mobile networks were controlled by Israeli companies (see output 7). As output seven notes, following Foucault (2000), if we are never free of power relations and cannot jump outside them, then we should at least acknowledge their presence (or goals). Nonetheless, the intention of output three in retrospect was not to prove an ‘imaginary’ reality of benign mobile disruption and change but to recruit a range of future actors in opposition to the existing status quo that it assembled. Output three also disassembles the monolith of neoliberalism as a stable state by painting a picture of unstable decline, which also undermines a purpose of the education system:

> Any expectations that the education system prepares people for the adult economic, social, cultural, and political worlds face even more challenges: the global economic crisis is characterised by sovereign debt, banking failures, youth unemployment, unstable currencies, global recession, and the political

> crises of legitimacy and accountability within established institutions and the increase in political violence from non-state actors (Output 3, p.4).

Setting out a case for change

Output three sets out a case for progressive context-based education by proposing a teacher education curriculum that combines mobile devices with other actors, and outlines the need for all to be joined. As such, the direction of output three is both innovative and challenging; however, the mobile is seen as the 'catalyst' and so the proposal is asymmetrical, favouring technology but also realising that 'in particular cases, social relations may shape machines, or machine relations shape their social counterparts [... and] usually matters are more complex' (Law 1992, p.3). Output three sets out five key tasks for a mobile facilitated teacher education curriculum which could be related to any of the five outlined educational purposes, depending on context. In fact, although the output talks of transformation it does not suppose, to its credit perhaps, which educational purposes should be pursued:

1. Implement digital tools in learning and reflect on their use;
2. Understand the match or fit between existing curricula and the emerging digital capabilities of learners and how these might be leveraged for learning purposes;
3. Understand the potential for change in teachers' roles and identities;
4. Use different pedagogical approaches that increase learner agency;
5. Use digital tools in context in reflective practice-based teacher education (Output 3, p.7).

The paper recruits the practice of reflection in teacher education (Schon 1983, 1987, 1991; Brookfield 1995) but critiques its application, noting that reflection is context- and value-dependent. Where located within an existing paradigm, there is little opportunity to consider other possibilities. Although Brookfield offers other lenses through which to reflect, reflection is often a singular human act and, disruptive change is unlikely to be achieved by a single human actor . Understanding 'match or fit' accepts curricula as extant monoliths, in that learners' habits must be matched to them and there is little room for transformation unless curriculum is adjusted also (*see* output 4). Equally, role and identity changes may occur as a result of learning design changes, as seen in outputs 1–2 but not necessarily just by the adoption of digital mobility. Again, this highlights the complexity required for a change in an educational system, and the different goals that various actors may have. Point four above is probably the most likely to affect transformation (see outputs 1–2 and 7), but without a purpose or the support of other actors in the wider system it is unlikely to be sustainable. Likewise, the addition of digital tools for a particular purpose may allow teachers to use them in their own practice, but without wider support any change would be isolated. A key factor above is that the output looks for agency within single actors rather than within a dynamic network of actors combined for a purpose. In this regard, Law (1992) notes that:

> Social agents are never located in bodies alone, […] an actor is a patterned network of heterogeneous relations, or an effect produced by such a network. The argument is that thinking, acting, writing, loving, earning —all the attributes that we normally ascribe to human beings, are generated in networks that pass through and ramify both within and beyond the body. Hence the term, actor-network —an actor is also, always, a network (p.4).

It follows that in assembling a network, purpose is important and at a level of granularity at which a particular network can act.

Actors without purpose

In terms of educational transformation, it is important to focus on network effects and the patterns of heterogenous actors, bound by purpose, that produce them in specific contexts. Output three omits both a context and purpose for the implementation of reflective practice and a new curriculum based on the use of mobiles. Each of the five points above are interconnected but there is no working model, and each is treated separately. The paper advocates for mobiles as tools rather than as delivery systems for existing curricula (Output 3, p.6) and emphasises a 'need' to use the digital in education pervasively, whether in the form of tools or habits. Output three does have potential for symmetry by including participatory pedagogies and digital habits and introduces capability and agility for the first time. As such, it has all the necessary ingredients for others to consider in their own implementation, but is still too unintentionally focused on the device. A representation of the potential actors for output three is considered in Figure 15)

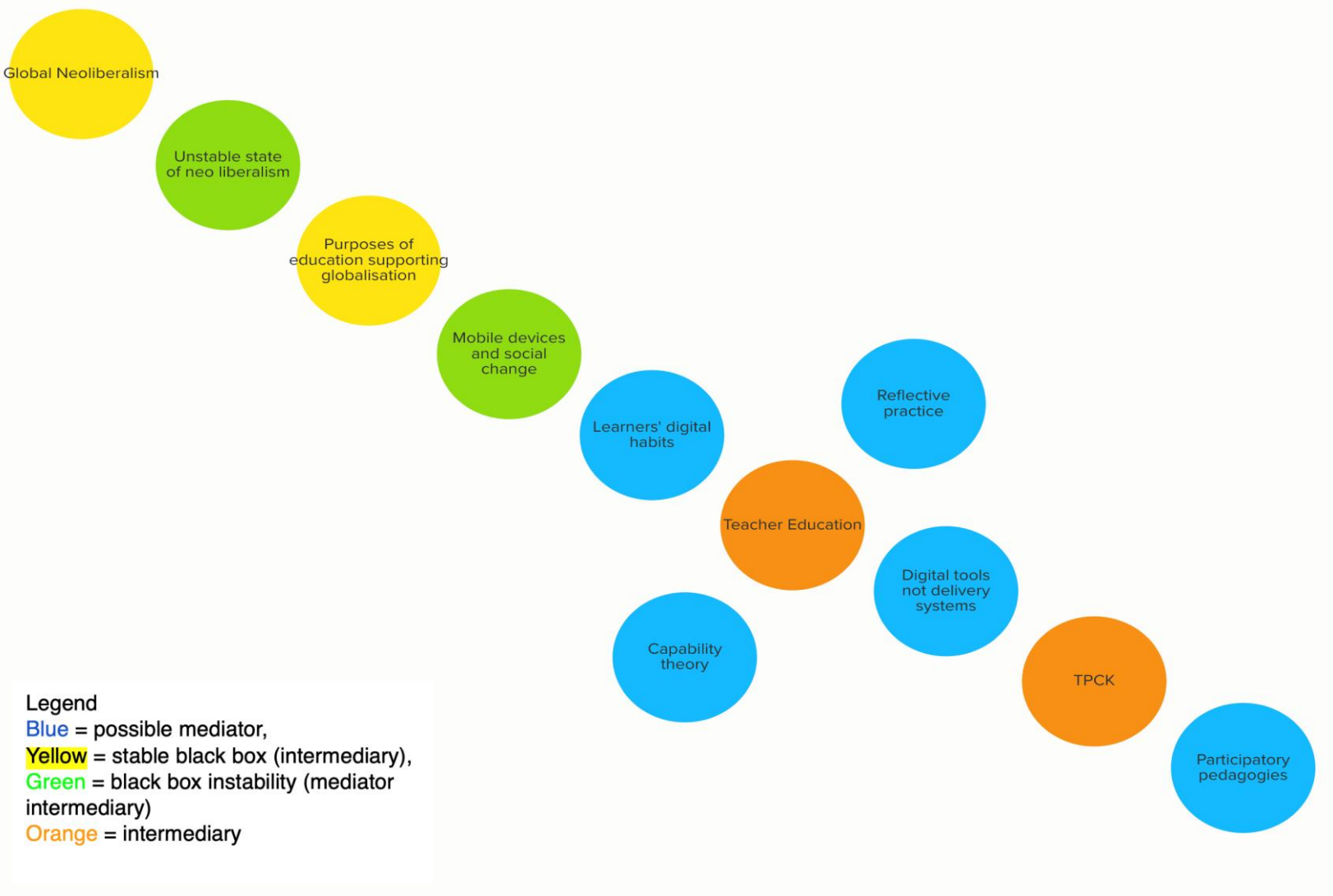

Figure 15. Potential actors in Output 3.

TPCK (Tondeur et al. 2012) refers to technological, pedagogical content knowledge. Which, it is argued, teachers need to integrate digital technology.

In Figure 15, the items in the paper are represented as entities with different qualities. The legend illustrates how each entity could act when assembled in a network by a defining purpose. The output presents a series of oppositions. The purposes of education supporting globalisation are set up to be affected by ‘mobile devices and social change’. Similarly, global neoliberalism is challenged in the output by the references to a construct of neoliberalism as unstable. Output three supports this juxtaposition by describing existing education and educational technology as ‘stable and monolithic’, whereas mobile devices are fluid, dynamic and part of a potential fundamental change. Latour (2005) argues that some actors ‘play the role of fully determined—and thus of fully “explained” intermediaries’ (Latour 2005, p.137) while others need a description of their actual roles as they function in a network, but no explanation. He decries the idea that stable elements can just be ‘lazily’ added: ‘If connections are established between sites, it should be done through more descriptions, not by suddenly taking a free ride through all-terrain entities like Society, Capitalism, Empire, Norms, Individualism, Fields, and so on’ (Latour 2005, p.137). It occurs to me here that this is also what I have done with neoliberalism in this retrospective, which I have taken as a ‘punctualised’ given. However, the broader questions in an ANT analysis are how neoliberalism is manifested in an AN, and how it might act against any change . If neoliberalism is black boxed and punctualised throughout to an extent it is a constant presence of which I am aware, and being aware of it means that I can look for actors that work on its behalf. Details of actors are important in ANs to define who and what acts to create network effects.

Schon's work (1973), where knowledge is said to arrive at the centre from the periphery, was recruited in output three to undermine the idea of the 'stable state' in favour of a connected, global —yet local notion —of situated learning. Intermediaries and possible mediators were identified above, should such a network be purposively assembled. Latour (2005) notes that the task is 'to deploy actors as networks of mediations —hence the hyphen in the composite word 'actor-net-work'(Latour 2005, p.147). Here, the focus is on what (work) the actors actually do and achieve, similar to the capability approach, which is concerned with the 'being and doings' or 'capabilities and functioning' of people.

As mentioned previously, many possibly important actors disappear, and qualities are attributed to others even though there is no account of them acting. For example, some technologies are classified as good (mobiles) and others bad (VLE) due to the 'constructed' work that they are purported to undertake. However, Law (2003) notes that this othering, black boxing and punctualising is a necessary 'Crafting and enacting of boundaries between presence, manifest absence and otherness [...]. Each category depends on the others, so it is not that they can be avoided. To put it differently, there will always be othering. What is brought to presence —or manifest absence —is always limited, always potentially contestable (p.85).

ANT also makes a bonfire of many of the oppositions on which output three is based:

> Actor network theory is a ruthless application of semiotics. It tells that entities take their form and acquire their attributes as a result of their relations with other entities. In this scheme of things, entities have no inherent qualities: essentialist divisions are thrown on the bonfire of the dualisms. Truth and

> falsehood. Large and small. Agency and structure. Human and nonhuman. Before and after. Knowledge and power. Context and content. Materiality and sociality. Activity and passivity. In one way or another, all of these divides have been rubbished in work undertaken in the name of actor-network theory (Law 1999, p.3).

At this point, I wonder if ANT analysis constructs too harsh a judgment on the positions taken in good faith in these earlier outputs . Output 3 did after all introduce the positives of capability theory and AWP into my work, but perhaps this is the nature of retrospective analysis and interpreting the past through the lens of the present (Carr 1961). Indeed, both outputs 1–2 drew different realisations about how human actors and technologies are entwined in any endeavour, leading to different foci in subsequent outputs. Equally, they developed the idea of agentic pedagogies, if a little embryonically. In retrospect, although ANT treats them harshly, I see their value in forming my practice and output three is no different in this regard. I wonder too now whether the style was too polemic and ardent in presenting the case for mobile technology as being so disruptive of both knowledge and society that it might change the status quo in education, as it has in other areas. Conversely, perhaps this was its purpose, to offer a challenge to the globalisation of ideas and present an opportunity to transform teacher education, and therefore teaching, based on the idea of a disrupted future in which new models of contextual place-based education are possible. In this regard, the paper is optimistic by offering alternatives for those willing to consider the possibilities engendered by mobile devices in a variety of learning contexts.

Consequently, output three can be seen as a punctualisation in and of itself as it wraps issues into an argument about ubiquitous technology in teacher education and possible approaches to learning that might be developed. As such, the text may become part of another (active) Actor Network (an immutable mobile) and some of the ideas within recruited to support others' actions and assemblages (like the creative curriculum in output 2). Indeed, Law (1992 op cit.) notes that resources (for use in networks) may come in a variety of forms (see previously) of which 'texts' are but one.

Output three has been cited 24 times in various studies, which perhaps used it as an actant. The titles shown in Figure 16 below may bear this assumption out, begging the question whether output three does in fact have a purpose to propagate teacher education with mobiles, and it has achieved this as an actor in other assemblages.

Titles of 24 citations of Output 3

1. Redesigning a Pedagogical Model for Scaffolding Dialogical, Digital and Deep Learning in Vocational Teacher Education
2. Creating opportunities for untethered learning
3. Innovative Learning Environments and Teacher Change: Defining key concepts
4. The effect of mobile learning applications on students' academic achievement and attitudes toward mobile learning
5. An embedded fuzzy analytic hierarchy process for evaluating lecturers' conceptions of teaching and learning
6. A comparative study about mobile learning in Iberian Peninsula Universities: Are Professors Ready?
7. Conceptualizing Open Educational Practices through the Lens of Constructive Alignment
8. Investigating and Critiquing Teacher Educators' Mobile Learning
9. Aprendizagem móvel no contexto de formação continuada: um estudo sobre affordances emergentes de interações de professores de inglês via WhatsApp
10. Exploring mobile learning in the Third Space
11. Enhancing Teacher Education in Primary Mathematics with Mobile Technologies
12. Changing knowledge, changing technology: implications for teacher education futures
13. Learning with Mobile Devices Perceptions of Students and Teachers at Lower Secondary Schools in Austria
14. Proceedings of the 2nd International Conference on the Use of iPads in Higher Education - ihe2016
15. Barriers and Challenges Facing Pre-Service Teachers Use of Mobile Technologies for Teaching and Learning
16. A typology of agency in new generation learning environments: emerging relational, ecological and new material considerations
17. Teachers' technology adoption and practices: lessons learned from the IWB phenomenon
18. Authentic, dialogical knowledge construction: a blended and mobile teacher education programme
19. Current Trends in Technology-Enhanced Learning
20. Disrupting Education Using Smart Mobile Pedagogies: Smart Pedagogy for Technology Enhanced Learning
21. Lenses on Mobility
22. Principles Underpinning Innovative Mobile Learning: Stakeholders' Priorities
23. When Teacher Education Goes Mobile: A Study on Complex Emergence
24. The Adoption of Mobile Devices as Digital Tools for Seamless Learning

Figure 16. Possible impacts of output 3 as an actor in other networks

Output three highlights the requirement for purpose within ANT and to consider what acts and how. Large social constructs such as neoliberalism need to be explored regarding how they are made manifest by the use of artefacts within a network. For example, an assessment policy that only allows one form of assessment is not equitable and may need to be challenged and created anew by an AN in its efforts to construct new realities and transform the status quo. As Latour suggests, 'both god and the devil is in the detail, so show me the detail' (2005, p.137).

In this example, it is not enough to say 'ah it's neoliberalism or 'the university' wants us to teach more hours. How is that made manifest? What acts so that we might counter it by acting back? The following analysis considers further the disappearance of groups and actors from a project by looking at how boundaries for

investigation might arise. It also looks at education's alignment with industrial processes, coupled to issues arising from the absence of a purpose for action. Further, it shows how (unlike in outputs 1–2) the digital habits of learners are used selectively by the project for its own ends.

Output 4. Education as industry: fitting the target audience to the needs of the 'delivery' system

Output 4. Keskin, N. O. Royle, K. (2015) 'Examining digital literacy competences and learning habits of open and distance learners,' *Contemporary Educational Technology*, 6(1), pp.74-90.

Output 4 looks at the implementation of a change within a large-scale online learning system predicated on learners' digital habits and a shift to mobile devices. In 1996, the Tomlinson report into inclusive learning stated, 'Put simply, we want to avoid a viewpoint which locates the difficulty or deficit with the student and focus instead on the capacity of the educational institution to understand and respond to the individual learner's requirement' (Tomlinson 1997, p.4). This view underpinned my thinking about making learning more accessible and equitable. I believed that how things were taught could be adapted to learners' needs, which would influence the design of curriculum, pedagogy and assessment. Output four exemplifies an industrial model of education (at scale) as referred to in output three (p.4) relating e learning to an industrial production line developed for accountability, throughput, and consistency. The context of output four is Anadolu University in Turkey, a 'mega university' serving over 1.5 million open and distance learners through various delivery options, such as virtual classrooms, e-learning portals, e-portfolio systems,

and interactive books. The learners are quite diverse regarding age, digital literacy competencies, and learning habits (Output 4 p.74). Output 4 was located in the educational purpose of a preparation for life and work which was not dissimilar to the position I held previously. As a corollary, this aim required learners to prepare for learning through Anadolu's various online, e-learning systems. The project focused on 'the abilities of Anadolu University's open and distance learners to use digital technologies in digital life and […] for the purpose of effective learning' (Output 4, p.75). The investigation of students' digital habits was to both gauge and then 'improve' their digital literacy. The paper set out a notion of what skills and abilities a 'digitally literate' person might need to function in society, juxtaposed against the actual 'digital' habits of students. The output aligned with a belief in the agency of: acquiring digital literacy; the mobile digital device; and, individuals achieving in education through becoming 'digitally literate'. This was thought to be because 'Digital literacy encourages curiosity and creativity and also enables the individual to evaluate the information that has been gathered in a critical way. By increasing the ability to use digital resources, digital literacy helps individuals feel themselves relatively secure at technology usage' (McLoughlin, 2011) (Output 4, p.76).

Who or what acts?

As noted previously, in output 4, who or what acts is presented asymmetrically. Technology as object is the main actor and learners are consumers of digital literacy and can acquire skills by engaging — 'Wikis promote collaboration and Google Docs encourages teamwork' (Output 4, p.77). The assumption here is that learners need to be taught digital literacy skills to become effective in society, and that, once achieved, learners can access a digitally-mediated curriculum and have the right

skills for success in the distributed global economy. As in output one, the students' voice is absent from the study; also, assumptions were made about their needs regarding effective study, which were mostly predicated on technological demands. I am reminded again of, 'who speaks for whom, who represents whom' (Callon 1984, op. cit) in this construction of power relations. In the study, 21,000 respondents completed a learning styles and digital habits survey, validated using Cronbach's alpha scale and a reliability coefficient of 0.74 was found. This meant that the survey gave reliable results, supporting its power and position in the study. At the time, it seemed that I was progressively incorporating learners' views by analysing their skills base with a view to redesigning the curriculum. However, retrospectively, the study may have inducted learners into the university's pre-existing digital learning systems and established curriculum by investigating consumers' (learners') needs: 'For educators and designers, an awareness of their learners' digital habits should allow them to construct learning events that transfer those habits into institution derived formal digital learning' (Output 4, p.80). In reality, the survey's purpose, as output four notes, was to discover how far students preferred working compatibly with the proposed remote and distance learning and how much support they would need to do so (Output 4, p.79).

I held this position uncritically, probably because I was still aligned pragmatically to a purpose of education equated to 'a preparation for life and for work' (output 3). As previously, ANT analysis uncovers several 'black boxes' and unconsidered positions, in that the nature of the curriculum and learning design was not considered and learners are expected to adapt to the learning environment. The survey gave insights into learning preferences — 'through graphics or visuals, through listening, and

through written materials and also that they were “dependent” and preferred to be told what to do in face-to-face situations rather than work collaboratively online’ (Output 4, pp.88–9). These responses became homogenous generalisations in the survey’s conclusions, and that ended the learners’ involvement.

Actors that don’t act

Latour (2005) criticises ‘grouping’ for its arbitrariness and stabilising nature; once the student is a participant that ‘dislikes collaborative learning online’, they no longer act but become an attribute of ‘student learning’ that must be considered by designers, either by training participants to ‘like collaborative learning’ or avoid it. ‘If I want to have actors in my account, they have to do things, not to be placeholders; if they do something, they have to make a difference. If they make no difference, drop them, start the description anew’ (Latour 2005, p.154). By using the survey, I effectively punctualised the learners as an entity into fixed-state black-boxed intermediaries where they will do what is assigned to them. This is a very ‘industrial’ position in that, if education is seen as a mechanistic process, then participants will be enabled to work within this process rather than co-create the process anew in each iteration. Marx, quoted in Ingold, notes, ‘For unlike the craftsmen of earlier ages, who might apply their skills to a range of tasks or commissions, the detail worker of capitalist manufacture is rigidly trained to the performance of one limited operation within the overall production system’ (2000, p.309). Although the intention is not to compare tending machines on production lines with education per se, output four does describe an educational technology interfacing with students and as such both the learning design and its users need to be modified or trained respectively for the process to work. In this sense, the affordances of the VLE are designed around a

predetermined construct of pedagogy. Another observation is the use of the survey to reveal more about the learners to personalise their learning experience. Personalisation as a concept can mean individualised learning with personal plans and goals, or collaborative, student-initiated learning using participative/ collaborative approaches (Leadbeater, 2008; Redecker et al. 2011). In output four, personalisation is left undefined and black boxed and is represented as acquiring generic skills rather than developing skills for a particular purpose. In retrospect, the survey analysis seemed to construct deficit models of digital literacy within the student population: 'When digital literacy competence is analysed […], learners have the skills to use information and communication technologies at a basic level. They need training on how they can use the digital tools more efficiently for learning' (Output 4, p.88).

The study does not start with a positive view of learners' capabilities, although initially couched in these terms, and the findings focus more on what they cannot do. The learners are not actors other than as a component of the education process which needs training to be able to interact with the distance learning system (DLS). This favours an alignment with curricula that output three identified (understanding match or fit between curricula and digital capabilities of learners). Although this retrospective appears a little negative, this was not intentional, since output 4 attempted to address access to education across one of the largest distance learning programmes in Europe and perhaps could not step outside itself and its own scale requirements.

Finally, output four fails to consider how the Anadolu DLS is aligned with the neoliberal education paradigm, or, if it does, it is in the background and unworthy of a role (Law, 2003). Although this aspect is not central to the paper's research questions, issues that affect purpose should perhaps also be taken into account. The educational purpose is not articulated and, despite evidence of its existence perhaps being present within the curriculum and DLS pedagogical approaches, these are 'black boxed' and not opened for inspection or adaption. Similarly, the learners are surveyed but not consulted, and asked about preferences but not expected to contribute to the design of their learning. This lack of student presence means they do not act as their role is passive.

Market segmentation by educational research

The survey instrument does not shed light on student capabilities that might be developed; rather, it narrows the learners' choices for engaging with the e-learning curriculum, limiting their AF and focusing mainly on a human capital approach to education (*see* Robeyns 2005). If the mega university were a consumer electronics business the survey would be about target market segmentation and entitled, 'what do our users want'? It shows that learners like video and audio, for example, so this can help course content preparation. It would seem that the study's purpose is concerned with avoiding the disruption that digital delivery mechanisms might bring to a lucrative market if learners lack the required 'skills' to use them. Such a supply side system tries to be customer focused but actually constricts rather than expands its offer, and is counter to a capabilities approach focused on 'whether or not (resources) expand the real freedoms that people value' (UNESCO 2002, p.33).

The survey's final section considered the use of social software and sought to appropriate learner digital habits for learning purposes. I realise now that a faith in incorporating digital habits into formal education as a change strategy is misguided and asymmetrically focused. If nothing changes in the fabric of curriculum, pedagogy and assessment, alongside a purpose based on improving learner capabilities, then little transformation will occur regarding increased learner agency and engagement. The ANT analysis of output four (Fig. 17) explores this in more detail.

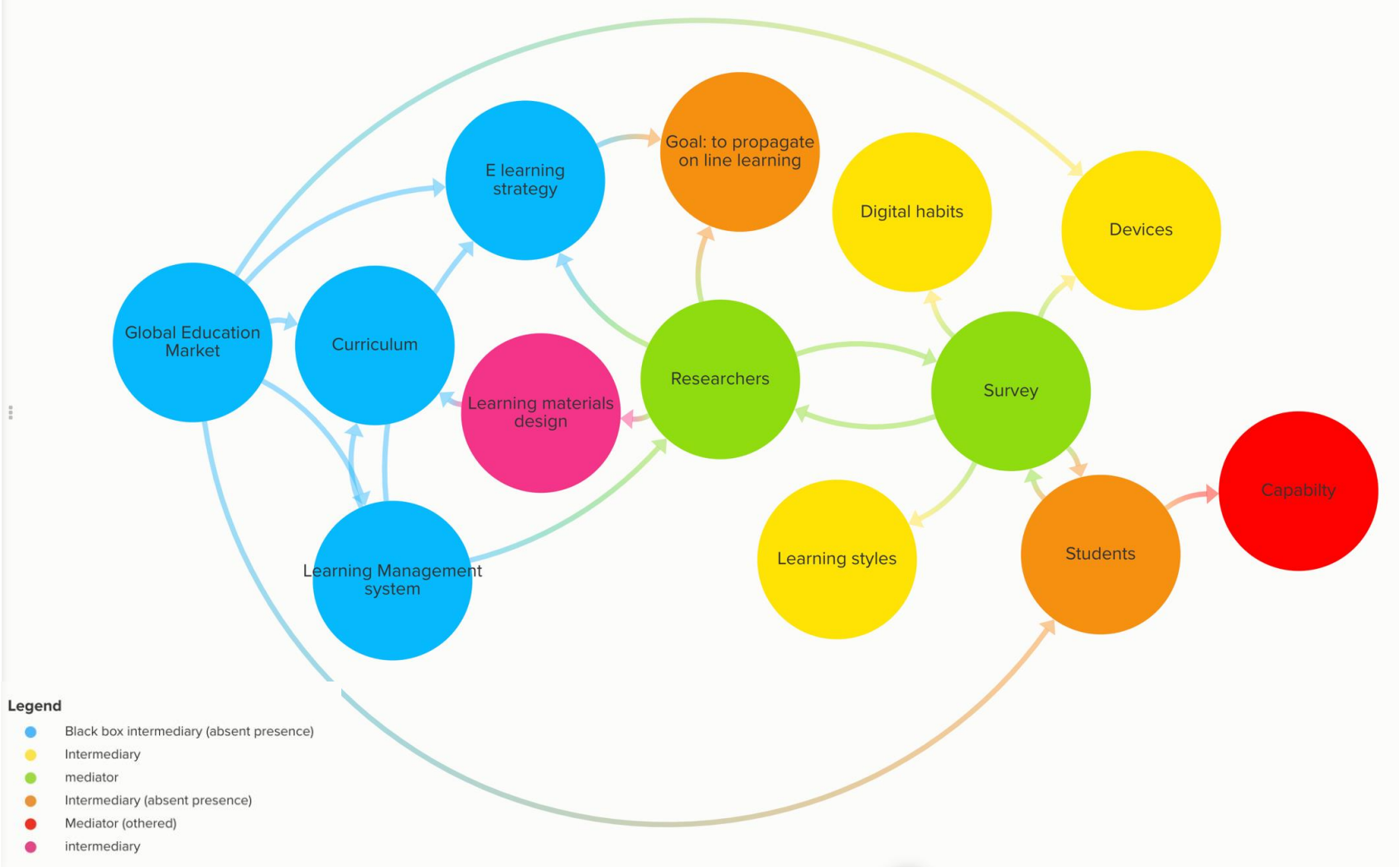

Figure 17. ANT representation of unmentioned things in output 4, showing how it was aligned to developing open/distance learning, not transforming how people learn

Transparency of goals, overarching purpose and what's in, what's out?

The ANT analysis map of output four has no overt or evident goals for each actor (except the researchers) in the network, nor an overarching purpose that is transparent for the project. ANT tells us to look only at what and how, but also notes the phenomena of absent presence (see also outputs 3–2) as a form of 'othering'. Law (2003) explains types of othering further as:

> There is the invisible work (for example) that helps to make a research report. There is the uninteresting, everything that seems to be not worth telling. There is the obvious, things that that everyone is taken to know. (but not always)
>
> And then, to ratchet up the metaphor and what is at stake, there is everything that is being repressed for one reason or another. Stick with repression. What is being repressed? Well, we don't know, do we? Not very well! But here is one suggestion. Everything that doesn't fit the standard package of common sense realism is being repressed. Everything that is not independent, prior, definite and singular (Law, 2003, p.8).

In Figure 17, a line could be drawn around the yellow and green items plus the students as the actors in a network. The survey is a mechanism/actant that transforms within this network, as are the researchers (both designated mediators). I have added capability to remind me of whether the intervention increases or decreases AF. I have made it manifest, but it is othered in reality —not important or considered. The blue items are more marginal and whether they are recorded as acting within this particular network depends on where you draw the boundary of the network (Law 2003; Strathern op cit). For example, Anadolu University, as part of the

educational market, are designing a new system based on mobile devices but does that influence the (green and yellow) actor network —is it important (made manifest) or is it othered? More evidence of texts and directives as actants is required to know how it might act and exert influence. Too often larger structures have effects attributed to them without examining how these effects have arisen. A better approach would only focus on what/who was acting in a network and then decide how to create a change by examining each actant/actors' goal, as they converge around an overarching problem. Also, by acknowledging what is othered, for example recognising that the educational context is part of an economic system, insights might be gained on how to 'act back' within that context to effect change. This could be something as simple as altering how assignments are graded from alpha numeric to pass fail: small acts of resistance.

Output five explores definitions of technology more broadly and broaches the subject of swapping technologies in and out of existing educational systems. Assessing impact and the notion of value and who constructs it in the CA is discussed. Education is conceptualised as a 'product' and alternative production systems based on (TPS , AWP) and agentic participation within agile frameworks are considered. It also looks closely at cognitive planning versus situated planning, and led to my readiness to embrace ANT ideas.

Output 5. Pedagogy as technology

Royle, K. and Nikolic, J. (2016) ‘A modern mixture, agency, capability, technology and 'Scrum': Agile work practices for learning and teaching in school,’ *Journal of Education & Social Policy*, 3(3), pp.37-47.

Mechanisms, techniques and planning

Output 5 was written due to my engagement with the agile community and a desire to use agile in education. In this output, I started to connect agency, pedagogy, technology and capability, and asked whether some actants are more likely to increase ‘AF’, realise capabilities, and convert them into functionings. On reflection, I started to wonder how agentic actors worked and if there was some generic mechanism or attribute to them. Whilst this is a little anti-ANT, which looks at combinations of actors and networked agency, I also looked more closely at whether agency is connected to a function as an intermediary or mediator. Output five considers how the agile framework is an agentic form of planning and, in this regard, Suchman (1985) notes that there are two main types of plan:

> Cognitive Science views the organization and significance of action as derived from plans, which are prerequisite to and prescribe action at whatever level of detail one might imagine. The second view, drawn from social science, treats plans as derivative from situated action. Situated action as such comprises necessarily *ad hoc* responses to the actions of others and to the contingencies of particular situations. (Suchman 1985, p.1).

This quotation summarises something I had realised as a project director of ‘social science’ interventions. Plans of the first type often do not represent what is actually

happening within a project and constitute an unsustainable desire for order. The second, based on situated action, relies on collaborative processes and communication, and are more connected to the realities of human endeavours. Plans are also used in education, from lesson plans to curricula and strategies for education. Adherence to 'planning' allows individuals to be judged against plans within a performative, contract-based structure (Olsen & Peters, 2005). Fenwick and Edwards (2012) found that certain actors can accumulate control over others through documentation: 'A teaching contract, for example, is a technology that embeds knowledge, both from networks that produced it and networks that have established its use, possibilities and constraints. In any employment arrangement, the contract can be ignored, manipulated in various ways, or ascribed different forms of power' (Fenwick & Edwards 2010, p.7). Thus, a method or 'gold standard' of lesson planning can become a judge of contractual performance in education, and the reasons for its presence, and how it was arrived at and established, are seldom questioned.

The Agile Manifesto (2001) favours 'responding to change over following a plan' and 'changing' customer requirements are a key aspect of production. In particular, the Agile 'Scrum framework' (Takeuchi & Nonaka 1986; Sutherland & Schwaber,1995) also uses self-organisation in its development process and situated action to create plans: 'This holistic [Scrum] approach has six characteristics: built-in instability, self-organizing project teams, overlapping development phases, "multi-learning," subtle control, and organizational transfer of learning.' (Takeuchi & Nonaka 1986, p.1).

Scrum in education

The ‘Scrum Beyond Software’ movement is used in contexts other than software development, including education. I started thinking about Scrum in education seriously around 2013 after I gave a talk at the Paris Global Scrum gathering about how it could be used in teaching. This resulted from work in schools in the West Midlands and was a collaboration with the co-author of output 5. In the same year, I presented at a UNESCO Chair’s symposium in Barcelona on the same theme and listened to Professor Yong Zhao on entrepreneurial or product-based collaborative learning (Zhao 2012). He presented two diagrams, reproduced below.

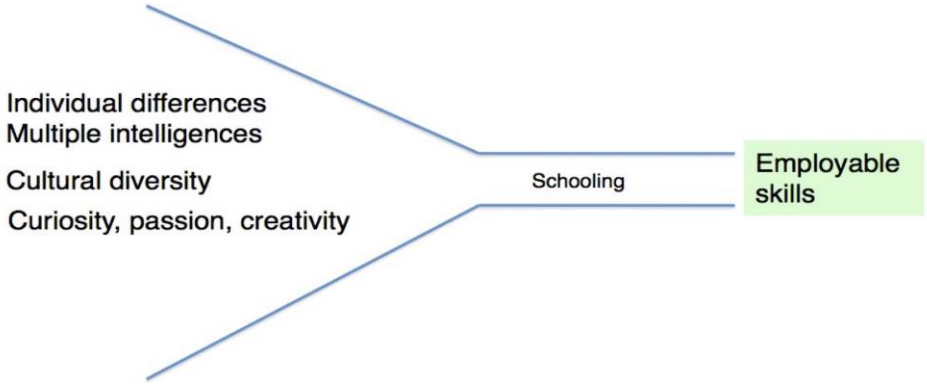

Figure 18. Zhao’s depiction of how schooling ‘standardises’ human capabilities and produces the wrong skills (2012, p.149)

In Figure 19, I adapted Zhao’s original second diagram (2012, p.153) to include a learning design or scrum-based framework in an expanded space that would scaffold project-based work.

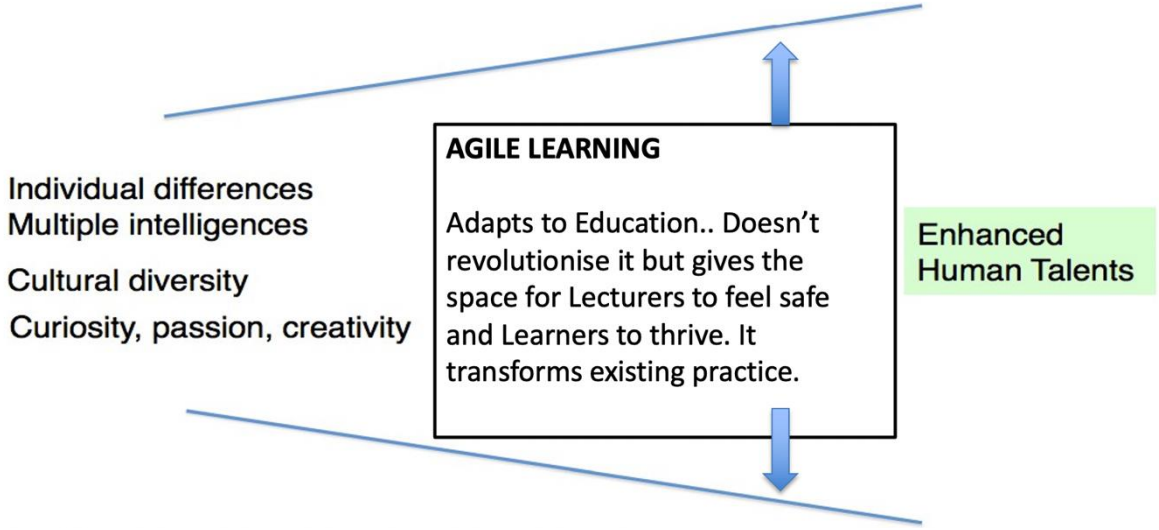

Figure 19. Agile learning 'opens a space' for learner-centred/teacher-designed collaborative learning

Figure 19 uses the phrase 'enhanced human talents' as an aspiration towards developing a range of capabilities in contrast to the human capital approach (*see* employable skills, Fig. 18.). At this time, I had a fairly mechanistic/instrumentalist understanding of Scrum and Agile, and although I understood how to implement them, I was unaware of their origins and rationale. I thought that if adapted for education, they would be a great scaffold for PBL, which, building on output two, would also give teachers control by taking a particular Scrum role; this would also minimise teachers' risk but allow learners to devise solutions. Here, I will not explore the deeper mechanics of Scrum as a simple framework for product development, but perhaps it is important to see: a) how it can mirror educational practices, and b) what underpins its success in certain circumstances.

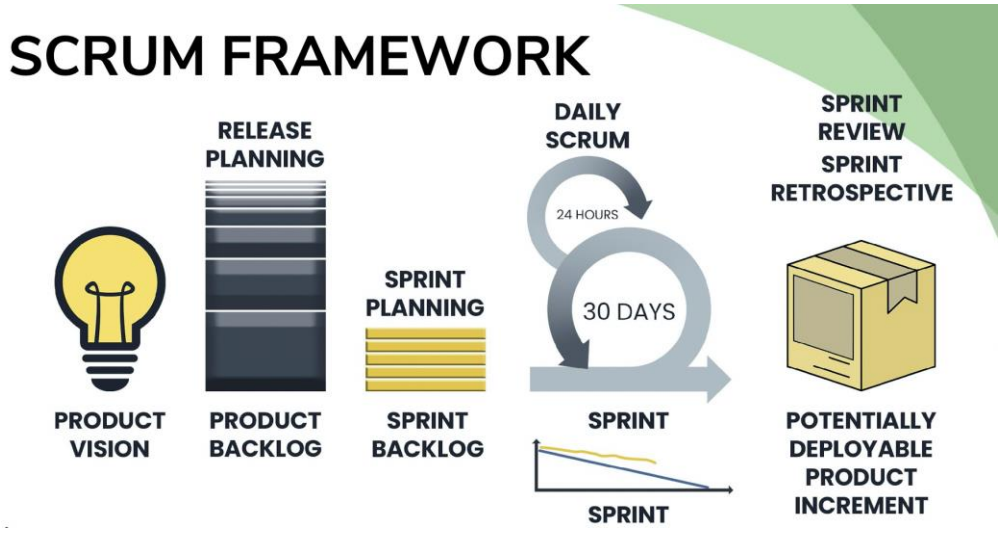

Figure 20. The Scrum product development framework (Agile Humans 2020)

Scrum in a nutshell

Scrum has three roles: the product owner, deciding what should be in the product (equating to the teacher role); the scrum master, facilitating the teamwork (also possibly a teacher role) and ensuring the scrum process is adhered to; and, the development team (learners), deciding how the work/product should be done/created (contrary to a classic learner role). A great deal of planning and prioritising (scheme of work/lesson planning) is needed before the work starts (product backlog and release planning) and small yet valuable, chunks of work are completed in time-boxed periods called sprints. A sprint can be up to four weeks or less —in a school it could be a lesson or series of lessons. Every sprint's goal is tied to the product vision so that people know why they are working. Every day, there is a daily scrum at the start of work when the team discusses activities. At the end of a sprint, there is a review of the quality of the items produced and a retrospective where the team reflects on how their collaboration and how they might improve.

Scrum, planning and self-organisation

Scrum is underpinned by SO and SM, (Ward 1966; Hackman 1995). Varying degrees of self-management are used in a variety of industries and, whilst uncommon, there are numerous examples (e.g. Patagonia Clothing, Morning Star Foods, FAVI Engineering) (Laloux 2014). Scrum has scaffolding/rules to maintain motivation and works towards the product vision as the goal of the company, rather than one collectively arrived at. However, in Scrum, agency and choice in how to achieve the product vision (control) is devolved to the team, and so perhaps the scrum framework (in part) is agentic, in and of itself.

Schwaber and Sutherland (1995) compared their embryonic Scrum framework with other methods (Fig. 21) (Schwaber & Sutherland 1995, p.11). The key comparison is between Scrum and Waterfall, which is a sequence of predetermined steps in a process (Royce 1970). This comparison highlights the emphasis on autonomous teamwork and control within the Scrum framework, and shows the degree of conventional planning at the start and end. This planning ‘halfway house’ was the attraction for using Scrum in education, because it was structured enough for teachers to maintain overall direction and free enough to release learner agency (in a team).

	Waterfall	Spiral	Iterative	SCRUM
Defined processes	Required	Required	Required	Planning & Closure only
Final product	Determined during planning	Determined during planning	Set during project	Set during project
Project cost	Determined during planning	Partially variable	Set during project	Set during project
Completion date	Determined during planning	Partially variable	Set during project	Set during project
Responsiveness to environment	Planning only	Planning primarily	At end of each iteration	**Throughout**
Team flexibility, creativity	Limited - cookbook approach	Limited - cookbook approach	Limited - cookbook approach	**Unlimited during iterations**
Knowledge transfer	Training prior to project	Training prior to project	Training prior to project	**Teamwork during project**
Probability of success	Low	Medium low	Medium	**High**

Figure 21. Scrum framework compared to other work processes (Schwaber & Sutherland 1995, p.11)

Another element of Agile and Scrum relevant to education is its focus on three pillars: **Inspection** of team processes/interactions/communication), **adaption** of methods —problem-solving in the context of a creative process, and **transparency,** so that everyone may know what everyone else is doing.

Scrum and increased human agency

With Scrum, the agency and creativity of the craft worker (Ingold 2000) is seemingly re-integrated into an industrial production process. Using Scrum in education can expand learner capability by promoting more choice for learners about how they do things (AF). This was quite a breakthrough moment for me in terms of developing authentic, participatory education. Scrum allows a loose-tight framework linked to authentic tasks that combines explicit knowledge and practice but with the role of **product owner** (responsibility for the overall outcomes) still being vested in the teacher. The issue of teachers transitioning to facilitators of learning (output 2) and

being more knowledgeable others (Vygotsky 1978) is resolved in the Scrum framework by its pre-identified roles. The notion of authenticity needed refining but Zhao's work (see Output 5, p.44) provides a gradual framework of de-controlling and developing learners such that they can design, research and develop solutions to problems within controlled projects, illustrated in Figure 22.

Table 1: Project Based Learning Models.

	Expected Outcome	**Control**	**Setting**
Academic model	Academic Content and outcomes	Teacher Led	Single classroom
Mixed Model	Product within constraints of academic requirements	Teacher and student collaboration	Single or multiple classes and community
Entrepreneurship model	Product	Student led	School and Community

Figure 22. Zhao's different learning models, with more or less teacher control (2012, p.199)

Relating to earlier comments (after Ingold) on the separation of process and skills and tacit (context dependent) versus explicit (non-context dependent) knowledge and the removal of human agency -Scrum blends both activities, reinforced in the Agile Manifesto (2001) which favours human interaction over production processes. The potential of Scrum in education thus lies within the idea of agentic collaborative endeavour through situated action with pre-defined goals within a structured framework.

Agile in education: a learning and teaching hybrid

Output 5 considers how Scrum can replace more directive teaching processes with scaffolded self-organisation 'without undermining the role of the teacher or sacrificing teacher control' (output 5, p.44). Agile learning and teaching is like a system virus or Trojan horse: it is a hybrid system, half planning and half free-form (*see* Fig. 21) and,

as such, is ideal as an ‘agency releasing mechanism’ to promote problem-based, authentic and participatory learning. Output five recognises the position and value of teaching, noting the lack of sustainability of previous projects (outputs 1–2) because of their ‘divergence from the perceived and valued functions of schooling’ (Output 5, p.40). Equally, output five repeats the value of reflection (output 3), comparing Agile’s ‘daily stand ups, product reviews and retrospectives’ with ‘double loop learning’ (Argyris & Schön 1983).

Output five does not discuss purpose and assumes education is about preparing people for work. It notes that, as ‘modern’ work practices change, education must reflect this: ‘Wherever the locus of control is located, be it at classroom, school or policy level a major paradigm shift is required that allows increased personal and collective agency to be enacted within existing organisational frameworks and structures’ (Output 5, p.41). Output five does not recognise that an unwitting alignment of education with a neoliberal economic model might also be modifiable, as it is bent on the reform of learning through increased learner agency.

Capabilities as an arbiter of learning efficacy

The CA (Sen 1992) is developed further in output five to evaluate whether a particular pedagogic approach or learning design affects individual rights and freedoms (Hart 2012). It is, ‘seen as a way of examining the efficacy of education and its impact on individuals… [to allow] us to think about the role, process and content of public education in innovative ways and to broaden strategic horizons beyond […] standardized testing, neoliberal discourses and quantitative policy directives’ (p.276).

Output five also introduces the ideas that personal, social or environmental circumstances (Robeyns 2005; Polishchuk & Rauschmayer, 2011) can influence the 'conversion' of capabilities to valued functioning (Output 5, p.39) and that particular individuals and groups are affected differently. In education, curricula, pedagogy and assessment provide the partial context and can limit conversion for some. Output five also raised the question of who/what decrees the value of a function in education, which is again linked to goals and purposes. However, output five was limited to acting within the existing educational paradigm, hence my attraction to Scrum's hybrid of control and self-organisation. I wanted something that worked within and yet modified the existing system:

> Commentators often decry formal education without really putting forward any concrete alternatives. Not all children can self-learn in public spaces or become coders or entrepreneurs, and mass schooling will not disappear in a digital whirlwind of change overnight. (Output 5, p.45).

I realise now that there is a danger that Scrum just becomes a new way of controlling young people so that they might match better to economic needs (*see* Eduscrum 2020). Indeed, Scrum is in danger of becoming its own educational orthodoxy.

My definition of technology expands

Output five introduced a wider view of technology rather than focusing solely on digital technology as a transforming actor. This wider ontology conceptualised pedagogical method as a technology (a purposeful method or process) that could combine technology objects and human actors in learning. At this point, I had not yet realised the larger possibilities for describing and analysing whole systems or

assemblies of actors, although Oosterlaken (2015) brought me close: ‘Tied up with this is the sociotechnical system or culture of learning into which the innovative “technology” is placed’ (Output 5, p.38).

Technology switching —what difference does it make?

Armed with the idea of pedagogy as technology (of process), I started to think about switching pedagogies and how the impact of such a change might be judged by recruiting the concepts of agency and capability (Output 5, p.39). I already understood that not all people similarly benefit from education and that some are restricted by its norms, but I started to seek ways of mitigating this through inserting mechanisms that promoted personal agency. Output five is a step towards thinking about how education can be more equitable and develop both ‘AF and agency achievement’ (Hart 2009). Output five was a pivotal moment as I brought concepts from other disciplines into education, allowing me to examine the existing organisation of learning in comparison to other methods of work and production. I had started to consider different constructs for designing or redesigning learning, but had not yet created a model for change. Output five, as a consequence and with the hindsight of this retrospective, enabled my acceptance of ANT conceptually, along with Foley and Lockton’s (2018) notion of actant switching, because they confirmed a view of education as a network of interacting components within a system. Output five is similar to output three in that it explores possibilities and ‘what ifs’ and lacks a case study. The ANT map is omitted here due to the similarities with output three, and yet output 3 is likewise one of my most read and downloaded papers. Further, output five introduces ideas and potential actors for later inclusion in an educational intervention design (outputs 7–8).

Output six below considers how ontologies can expand indefinitely in an AN, and how an expanded view might shift the initial focus of a project. It considers how curricula are developed both to include and exclude and whether all education or schooling is intrinsically good for all participants. The notion that interventions and system change might be created through heterogenous sociotechnical engineering as a construction rather than a retrospection is also explored.

Output 6. Capability and educational purpose: framing and designing mechanisms and outcomes

Output 6. Royle, K. (2017) 'Resilience programmes and their place in education: A critical review with reference to interventions in Wolverhampton,' *Journal of Education and Human Development,* 6(1), pp.1-8

Output six considers a funded project looking at the mental health and wellbeing agenda in Wolverhampton Schools and young people's response to interventions over a five-year period (2016–2020). The paper was based on a report into the early phases of the Big Lottery-funded Wolverhampton HeadStart project, to address risk factors associated with young people developing mental health difficulties in later life. As the paper notes, Wolverhampton has 'high levels of deprivation coupled to a post-industrialization backdrop with higher than average levels of unemployment. Output 6 questions 'the positioning of school-based resilience and wellbeing programmes as a solution to mental health against a backdrop of increasing deprivation' (Output 6, Abstract).

Output six was a counter-narrative to the uncritical way in which mental health and wellbeing became a ‘curriculum subject’ (Hinds 2019) and added to the responsibility of schools to fix society’s ills, predicated on increasing deprivation, the austerity agenda, and other inequalities such as access to work. Equally, the English education system’s high status examinations were also a source of stress for young people: ‘we might think here of the intense pressures placed on students in the name of individualised notions of aspiration and achievement, particularly in communities afflicted by poverty’ (Clarke 2018, p.10)

I think output six led me to see education and associated policies more clearly in terms of their outcomes and this ANT analysis has reinforced that. Another factor of interest was a movement from ‘building resilience through assets’, to embracing a ‘wellbeing agenda’. Initially, the project used Ungar’s (2006) definition of resilience on how assets around the child could be developed to support wellbeing. Ungar (2006) argues that resilience is not solely an individual quality or ability but also context-dependent. The HeadStart project tended to see schools as the key venue in which resilience might be developed in individuals, and progressively seemed to exclude other required potential actors and assets.

As in output five, the CA was used to consider whether the project’s interventions or mechanisms led to increased AF. Education is seen as a basic human good in the CA (Terzi 2004), but the latter reassesses this in terms of intrinsic value and its instrumental role in wider societal development (Hart 2015). The CA was recruited to interrogate whether the Wolverhampton HeadStart interventions widened opportunities or narrowed them, within a concept of schooling that, according to

Apple (2013) and McGregor (2009) aligns with the notion of developing human capital (Robeyns 2006) rather than human possibilities. In this output, it seemed that society's issues were blamed on schools, while those issues with schooling and underperformance were blamed on individuals. Young people were said to have low or the wrong sort of aspirations and identity capital. Côté (1996) and Warin (2013) were recruited to explain that young people need help to construct a notion of self that results in a positive relationship with teachers and schooling. One of the memes that was a constant in the early days of Wolverhampton HeadStart was 'dare to dream' —giving children the idea that anything was possible as long as they worked hard at school and 'aspired'. I currently find myself more aligned with Clarke's (2018) view that this notion is part of the neoliberal narrative, in that education is largely exclusionary and failure to achieve is rooted in individual shortcomings.

Output six also introduced the idea of therapeutic governance (Pupavac 2001; Nolan 1998; Ecclestone & Lewis 2014), the idea that state institutions locate difficulties in life within a deficit model of the individual or society:

> The therapeutic paradigm has become integral to how state institutions relate to citizens: in public life with the new 'politics of feeling'; in education with self-esteem displacing intellectual understanding as the goal; in family policy with the expansion of relationship counselling and the professionalization of parenting; in the economy with therapeutic support for the unemployed (Nolan 1998) (Output 6, p.54).

This idea made me see my context differently and contemplate how solutions to macro issues such as deprivation or unemployment could be equated with 'becoming more resilient', and other deficits within an individual. For example, youth

crime is often seen as a community or parenting problem rather than a result of youth club closures, deterioration in opportunities and publics, and a reduction in community policing. In contrast, interventions that allow young people to 'stay in school' through various means, such as modifying their behaviours in line with school policies, creating a form of identity capital through good relations with teachers, and setting aspirational goals, might be deemed to increase AF by allowing individuals to utilise an asset (school) that aids their well-being. School, in this case, is often looked at uncritically as an asset through which capabilities can be converted into valued functioning (Nussbaum 2011; Robeyns 2005).

In this scenario, resilience programmes are recruited into schooling as ways of regulating young people's behaviour by rising to difficult challenges. This was confirmed in Output 6, in which the intervention programmes reported an ability to regulate behaviour (Ecclestone & Brunila 2015), offering 'an acceptable identity and helpful strategies to children who experience emotional and behavioural problems' (p.497). However, Ecclestone and Lewis (2014) note that, 'Behavioural interventions avoid engagement with the enduring social structures that attend the adversity that makes resilience necessary, thereby diverting efforts to confront the social inequalities which cause adversities, efforts which are ultimately necessary for the resilience of social systems' (p.203).

A complex situation requires a wider view

It is challenging to decipher the complexity in output six to see what I have learned, but it is just as important to look at what was not considered in the HeadStart project to see the wider view. Focusing on one area of a network when others may have

more influence is something that researchers often have to do. Symmetry of analysis, where all actors are considered in order to comprehend the extent of a system, is something I have learned from using ANT. In output six, I focused on educational issues initially, notably the narrowed curriculum —'When one includes something in curricula one ultimately excludes something else' (Output 6, p.60), coupled with the causal loop of test-driven curricula and other social issues causing an increase in mental health and well-being 'problems' (Output 6, p.60). This paper crystallised my thinking about the need to reset the basis of schooling so that it draws its curriculum from its engagement with its context to make learning authentic, participatory and involving of the community. As such, the situation is similar to my own school experience and that in Zimbabwe when I taught a curriculum divorced from context, in that globalisation and deindustrialisation have removed connection and purpose from young peoples' lives in the more deprived parts of Wolverhampton. Such an unreconstructed education system (still serving past industrial needs) means that the population is not well served as, Clarke (2018) notes, since the system is,

> [a] cruelly optimistic promotion of a culture of success, underpinned by a belief that all can succeed and everyone can be a winner, in a context where university places and well-paid jobs are limited by the structures of the economy and in which one school's or one student's success must inevitably be accompanied by another's failure (p.10).

Zhao (2012) calls current schooling 'employment-oriented' education, dependent on conformity and standardisation. 'These education systems are good at imposing conformity and weeding out those that do not conform' (p.149). Wellbeing

programmes that are increasingly attached to schooling can be conceptualised as a well-meaning attempt to make or help people conform so they can prepare for work. Equally, they could be seen as a standardised response to the social deprivation pressures of living in a post-industrial region. Zhao also notes that the traditional paradigm survives because of its 'master plan for life's success' (p.161), which reduces children's progress to exam scores and competitive comparisons. This phenomenon can also be seen in the adoption of wellbeing into the curriculum. If the purpose of a common curriculum is to equip students with the knowledge and skills to function in society, any new addition must have a value for that society, and yet such additions may displace elements of curriculum based on different interpretations of value. Ecclestone and Lewis (2014) note how positive psychology approaches and CBT-derived training courses contest curriculum space with other subjects. Their value is arguably in getting students to engage and conform with the existing educational offer by inspecting their behaviours and adapting them to required norms rather than changing the norms of schooling and the learning paradigm (similar to output four). Once wellbeing becomes part of the curriculum, it can be assessed and seen as an essential part of education, as output six notes: 'School-based programmes of social and emotional learning therefore have the potential to help young people acquire the skills they need to make good academic progress' (Brooks 2014) (Output 6, p.60).

Heterogenous engineering of education: unravelling complexity

ANT facilitates the consideration of all actors (even those we ignore) as an assemblage around an issue, potentially allowing it to be re-engineered. First, the AN is described as perceived, and then an assemblage is created of how the AN

might be differently designed. Figure 23 outlines an ‘AN’ for the resilience/wellbeing interventions in Wolverhampton schools, incorporating actors additional to the schools and interventions which might be reconfigured to create something different.

Figure 23. A possible AN Map of a complex system, showing key actors for a future act of heterogenous engineering.

There are distinct clusters of actors in the network. The blue, pink and red items represent the AN where the intervention took place, bounding those who acted. The blue items act as intermediaries. The two resilience programmes are also intermediaries but are designated as mechanisms (defined here as a pedagogic technique/mechanism used as an intervention —this can be more or less agentic/mediator or intermediary; examples in previous outputs are PBL, surveys, and reflective practice) because of their intention to act; how they act is dependent on the purpose or goal of the intervention. The two programmes have methods and tools (mechanisms) within them that are not intended to transform anything other than the actions of the participants. These could be considered as controlling towards a norm or conversely could be expanding capabilities by allowing access to education as presented. Although the two programmes are ostensibly concerned with improving mental health, wellbeing and resilience, they are effectively enrolled to improve educational outcomes. There may be some personal gain for individuals who re-join the mainstream and gain more agency through completing formal education, and while this could be seen as improving AF, it may not be functioning that participants personally value. ‘Students who don’t conform’ and ‘identity capital’, are both designated here as mediators. Simply put, the non-conforming students may have a range of outcomes despite the intervention, as they may be unchanged and continue not to conform to schooling norms, or radically change and conform. Identity capital in this network may also be agentic/transformative depending on how linked it is to school norms. This designation is weak because the overarching paradigm is conformity, but the processes within the interventions may lead to deeper insights that young people can use to form another sense of identity and

follow a different path, whether or not it is pro-social or conventional. In this sense, different functioning may be converted from capabilities discovered during the wellbeing programmes.

Supporting a dysfunctional system

The cluster of green and orange items and the yellow item in Figure 23 are not part of the assemblage but are included because they are black boxes which influenced the central AN. In some ways, they have been recruited but are not involved. Hence, the orange items are black boxed intermediaries that support the established purpose of education and produce both conforming and non-conforming students. They carry weight that constructs a purpose of education focused on employment and growth, to resolve low attainment, low aspiration and any other ills within the indices of deprivation. Education is asked to address these issues although they cannot be addressed by education alone. In this paradigm, people are encouraged to participate in institutions ostensibly there to help them, no matter how dysfunctional this might be, so that mass deficits in skills, aspirations and health and wellbeing can be addressed.

The green items are black boxes that have absent presence because they are not articulated. For example, if one asked the teachers and headteacher what the purpose of education is, the answer would probably not be related solely to economic growth and employment. However, viable alternatives are not often articulated; even though they may be included in academic papers or taught on education courses, evidence of them in formal education is thin. The traditional dominant educational paradigm (of serving the economy) is self-maintaining (Zhao

2012, pp.146–141). Likewise, families, communities, austerity and deindustrialisation are all present in the network but absent. They are not seen as part of a solution but as problems that create low aspirations in a cycle of poverty. They are not part of the assemblage, even when HeadStart has programmes in the community, as these are disconnected from the educational purpose or project. Drucker (1997) and Stenhouse (1975) asserted that schools should work on community issues, but are left inward facing and separated from their community contexts in the drive to meet performance objectives. The value system of the school is often at odds with the needs of their learners and communities. As Dewey (1915) notes:

> We must conceive of [schools…] as agencies for bringing home to the child some of the primal necessities of community life […] as instrumentalities through which the school itself shall be made a genuine form of active community life, instead of a place set apart in which to learn lessons (p.11).

In Figure 23, items in yellow are othered black boxes that are un-noted or disappeared. On the left of the diagram, there is the ‘industrial’ legacy of semi-skilled employees experiencing the impact of de-industrialisation in an area which has not yet adjusted. Unlimited economic growth is uncritically accepted, and schools are seen as part of the solution to this as both providers of growth and social justice (Clarke 2018). There appears to be no alternative for the development of human capability in a post-industrial, post-austerity, post-carbon, post-viral, neoliberal economy other than continuing with a slightly amended version of the approach used for an industrial society —albeit predicated on a low skill, service-based economy.

Also in Figure 23 (right) are the othered items that could be used to redesign notions of community and education as part of a new assemblage of the social. Elements such as curriculum design could switch to a learner-centred model, and likewise the development of human capability become the 'purpose of education'. Similarly, the concept of therapeutic governance could act back by removing the educare element of wellbeing. Such notions, however, are simply speculations of design and need to be placed in a different conceptual purpose for education before they can be assembled.

This analysis has focused on the potential scope of any intervention and tried to set out all of the potential actors involved. The following analysis looks at why 'societal' problems are often considered too big to tackle and where efforts for change might be focused. It considers how 'mechanisms' might facilitate agency at a lower level of granularity and how a unifying 'purpose' and relatable individual goals are required at all levels.

Output 7. PBL as an agentic mechanism and transformational mediator

Royle, K. (2019) ‘Opening spaces for the development of human agency with problem based learning in Palestinian higher education,’ In: Uden L., Liberona D., Sanchez G., Rodríguez-González S. (eds) *Learning Technology for Education Challenges*. LTEC 2019. *Communications in Computer and Information Science*, 1011, pp. 260 - 278. Springer, Cham

Output 8. Actor network theory is employed for the first time

Output 8. Royle, K. (2020) ‘What’s good what’s bad? Conceptualising teaching and learning methods as technologies using actor network theory in the context of Palestinian higher education,’ *Postdigital Science and Education* (2020). https://doi.org/10.1007/s42438-020-00138-z

Outputs 7–8 are linked as the latter reassesses the former from an ANT perspective. Indeed, the current retrospective applies this notion to outputs 1–8. Outputs 7–8 are based on an Erasmus Plus project called ‘Modernization of Teaching Methodologies in Higher Education in Jordan and Palestine’ (METHODS). The METHODS project was initially concerned with introducing educational technology and e-learning approaches to augment existing practice based on the Moodle LMS. Wolverhampton University’s role was impact evaluation and we conducted digital habits and learning preference surveys (outputs 2 and 4) in Palestine and Jordan. Due to earlier work and teaching, I was more interested in changing pedagogical approaches (output 5) than introducing technologies into existing teaching and learning paradigms. Since a project partner, Aalborg University, predominantly used PBL, this provided an

opportunity to propagate it. The Jordanian universities saw e-learning as a solution for mass delivery in an oversubscribed sector. There was also interest in 'flipped learning' (Roehl, Reddy & Shannon 2013) in Jordan due to poor engagement and attendance in engineering classes, while in Palestine the lead academic, an electronics engineer, was interested in developing an open learning platform and PBL. In our first meeting in Copenhagen, we decided on three learning modalities 'PBL, flipped learning (problem-based) and the creation of learning resources to support Massive Open Online Course (MOOC) development' (Output 7, p.260). A professional development programme which allowed individuals both to experience PBL in a university context and design courses using flipped strategies, PBL or Moocs supported implementation.

The Jordanian and Palestinian universities engaged differently (Output 7, p.265). The latter chose mainly PBL and students appeared to have shifted their learning preferences from the didactic to the collaborative (as per the survey evidence). Although this was not unusual as collaboration is part of the PBL method, it was remarkable in a normally didactic, lecture-based system, which Roehl, Reddy and Shannon (2013) note continues to be a predominant HE strategy (even when digital). Palestinian HE is both very competitive and standardised and divergent methods are usually resisted, as a lecturer at Bethlehem University noted: 'We get an inflow of students that are very traditional with this type of lecturing —indoctrination, exam-based. This continues at university. The students put high pressure on their teachers against any new approach '(Output 7, p.274). The ready acceptance of PBL in Palestine made me investigate further, and I conducted some semi-structured interviews to ask students and staff about their experience. Thinking back to output

five, I wondered how PBL might have released agency and opened a space for participatory learning and in the skills/attributes that students and staff might acquire. My knowledge of the Palestinian context made me consider the dynamics of power more closely. Although I was aware of power dynamics in UK education, such as class, gender and ethnicity, in Palestine the politics of the occupation are ever present, and exercised so starkly, that you accept its presence, as output seven notes, ‘The exercise of power over the Palestinian people by the occupation permeates directly and indirectly into the lives and activities of students and lecturers’ (p.261). On considering power, I looked to Foucault (2000) and his discussion of how people self-police inside the structures of society and education. As output seven notes: ’Foucault’s (1975) notion of education as being part of the extension of social control whereby we police ourselves through our own institutions and we fabricate docile citizens through education would seem to obviate the very notion of human agency’ (p.264). In Palestine, there are considerable constraints on personal agency and the educational context is characterised by low graduate employment and outsourced working, coupled with restrictions on travel. The adoption of PBL in this situation meant a move from objective-led, content-heavy approaches to looser more open patterns of student engagement and participation counter to the climate of control in Palestine.

Again, I recruited the CA and AF and equated this to increased choice about how to learn and what problems were chosen through PBL. Notes of caution were entered using Tobias’s (2005) warning against the reification of agential freedom without considering the context. When faced with large ‘realities of the social’ where things seem insurmountable it seems unhelpful to talk of AF and of pursuing agency as an

educational imperative (Cauce & Gordon, 2013). However, in Palestine, this is both the reality and mundanity of the occupation and it is perhaps incumbent to practise agency and resistance wherever possible. Law (1992) notes that, ‘notwithstanding the dreams of dictators and normative sociologists, there is no such thing as “the social order” with a single centre, or a single set of stable relations. Rather, there are orders, in the plural. And, of course, there are resistances’ (p.5).

Smooth and striated space

ANT focuses on assemblages that act to either transform or maintain the status quo within a bounded network (Latour 1996). Using ANT means the occupation can be treated as a black box that does not need to be opened, similar to the larger box of neo-liberalism, because what is important is that which acts within a network to solve an issue or problem. Output seven quoted Foucault’s (2000) later work, contributing that agency can act against powerful forces: ‘We are always free; we can always resist; our ongoing task is to construct ‘arts of living’ that might counter the manifold expressions of ‘fascism’ that lurk throughout institutions, systems, relations, and even ourselves’ (p.264).

I conducted interviews in Birzeit, Hebron, Bethlehem and Nablus, driving each day from Ramallah along ‘Palestinian’ roads which skirt illegal Israeli settlements and require long detours because of checkpoints. Whilst driving, I realised that space is always contested and in Palestine it is restricted and cut by fences, razor wire and walls. Consequently, educators must open space for agentic choice wherever possible, especially in an area where resources, places, people and material are restricted and controlled, to consider the issues in context (output 6) and offer

solutions. A lecturer from Al Najah agreed, ‘I think it’s a must in our education system because we need students who are problem solvers. I think it’s a national thing [...] we need to create a nation of problem solvers’ (Output 7, p.275).

During output seven, I became fascinated with Deleuze and Guttari’s (1988) notion of smooth (nomad) and striated (state) spaces. I first met these after reading Bayne (2004), who likened the e-learning walled gardens that universities were establishing as citadels of striation on the smooth open plain of the web. Zhao’s (2012) diagrams of opening rather than closing funnels (output 5) also gave me the idea that certain mechanisms/actants/techniques/methods might open a striated space and make it smooth for a while. This notion seems to fit with SO (Brand 2016; Ward 1966), which relies on a certain direction or goal being created (rather than a prescribed path) but how you arrive is down to the person/people in the space —hence a release of agency. Bayne also notes that smooth and striated are not good/bad opposites but just where different things can happen. These ideas draw heavily on Deleuze and Guattari (1988), who note, ‘Of course, smooth spaces are not in themselves liberatory. But the struggle is changed or displaced in them, and life reconstitutes its stakes, confronts new obstacles, invents new paces, switches adversaries. Never believe that a smooth space will suffice to save us’ (p.500). This is the affordance of PBL in output seven, as in each context it appeared to transform and act as a mediator, opening a space in the striated orthodoxy of the dominant educational paradigm where previously inputs led to predetermined outputs. PBL changed the power dynamic and purpose of learning, by releasing agency to learners and also modifying the role of lecturers. Equally, it also left physical traces of its passing on the built pedagogy (Monahan 2002) of the institution (Output 7, p.263).

PBL as agentic mechanism

Unlike Scrum (Output 5), PBL is easy to implement, despite having several different versions (Savin-Baden 2014). The Aalborg model used in METHODS is based on Graaf and Kolmos (2003), and has variable learner control and agency (*see* also Zhao, Fig. 22). PBL is modifiable by other actors, as it lets them participate and shape it and so it fits with what lecturers find comfortable (Output 7, p.261). PBL is also a mediator (Latour 2005) as an actant because it transforms, the outcomes are context-dependent, and it is fluid (Laet & Mol 2000). It transforms not only pedagogy but also curricula (the problems recruited to PBL were located in the authentic issues of the community) and assessment (altered to fit the students' authentic solutions). Depending on the degree of autonomy provided to students, the lecturers started to scaffold learning with more or less striation by making rules and checkpoints, although they carefully retained the choice of initial problem or plan, how students arrived there, and what the assessment might be was predominantly left with the learners. This is counter to Scrum, where the initial product/project planning and closure are controlled. Some lecturers did seek to control these areas too and created competency frameworks to tie things back to curricula. However, in more autonomous examples where students had more control and self-organisation, they proclaimed whether their solution worked and set their own success criteria based on their achievements, even including learning from failure. The effect on curricula, pedagogy and assessment was the most interesting outcome, stemming as it did from 'just' a change in pedagogy. How this change was judged was through the interrogative framework of the focus groups and interviews, detailed further in output seven.

What did PBL do?

After the interviews, new themes emerged including: confidence or willingness to try; the sustainability of the PBL method and its evident reach beyond the project participants; flattening of power relationships; the pedagogy affecting the curriculum and assessment (after Bernstein) —transformation was growing and I titled this section of the paper, **Changing one thing (pedagogy) ultimately means changing everything.** I was shocked by the degree of change afforded by PBL and the participants' consistent responses across the emerging themes. I thought that something was happening that could not be explained only by PBL as a pedagogy, and yet I was still looking at things asymmetrically. I had merely replaced one form of technological determinism with another. Finally, in output seven, I drew conclusions about PBL in the methods project. The first was based on its simplicity of design, applicability and adaptability across contexts. The simple Aalborg model asks lecturers to problematise existing courses rather than make courses anew, and so it is like a 'Trojan Horse' as, once started, other aspects of learning design also require change (the curriculum becomes more authentic and drawn from the community, and assessment changes to see if a solution has been found). Second, PBL increased engagement and agency, as power and responsibility shifted to the learners. Third was the conscious need (a goal from lecturers) to develop learners' critical thinking and collaborative skills. Fourthly, digital tools were integrated into practice by PBL rather than as delivery systems (see output three), where they could mitigate occupation-based structural issues. This evidence confirmed that PBL as a mechanism was acting as a mediator (Latour 2005), where the actant transforms and causes change and innovation.

Accidents will happen: discovering ANT through Actant Switching

Although I concluded that the project's changes seemed to be by accident (Output 7, p.275), I was intrigued to know what had happened: was it PBL acting alone or the coinciding of PBL with Palestinian 'collaborative endeavour' and a genuine desire to act on problems, fired by the occupation and the adversities of living in the West Bank? I still believed that pedagogy was key to change and, although I had been anti-technological determinism since output two, I had not yet deconstructed PBL as a technology despite output five. If I had not read Foley and Lockton's (2018) paper on actant switching, I would still be in a binary mode, championing agentic pedagogies as sole change agents. Foley and Lockton used ANT to map out a heterogenous network of actors and then engaged the idea of actant switching and speculative design through service fictions (SF), which they define as : 'Actant Switching (AS) is a method for speculative scenario creation that interchanges human and nonhuman actors to create counterfactual scenarios, exposing tension with the context and technology. Service Fictions (SF) is a method for engaging participants in a co-created speculative design around the created Actant Switching scenarios' (Foley & Lockton 2018, p.1). Yaneva (quoted in Foley & Lockton 2018, p.203) notes, 'a thing or a design project can modify all the elements that try to contextualize it, triggering contextual mutations. In this sense, a design project or a disputed design resembles more a complex ecology than it does a static object' (Yaneva 2009, p.284). Laet and Mol's (2000) paper on the Zimbabwe Bush Pump, the Mechanics of a Fluid Technology, also influenced my thinking. This was a revelation in cementing the premise of ANT, partly because I understood the context (Zimbabwe) and partly because the pump is written about as an actor with agency. Equally, the concept of fluidity (Laet & Mol 2000, p.225) struck a chord. In output

seven, PBL was differently implemented in similar contexts, but with varying degrees of risk, scaffolding, learner agency and control. It was this very fluidity of the PBL ‘scaffold’, as opposed to the ‘Scrum framework’, that made it adaptable and simple.

For several years, I had championed pedagogy and people over digital tools and proposed the notion that there was ‘no agency’ in (digital) technology, despite arguing for a wider definition of technology in several papers. I now started to see learning design as a fluid technique within a network, as this would account for the changes in other actors such as assessment, teachers, learners and curricula. I did not see the asymmetry in judging technologies as separate entities rather than as part of a network of actors, and that agency was located within combinations of these actors. ANT (combined with agile system thinking) opened my eyes to the possibilities this held not only for the evaluation of educational interventions but also for their design. Could this perhaps explain the Palestine PBL phenomena? I used output eight as a vehicle to explore this by attempting to re-examine the data from output seven through an ANT lens.

Output 8. In educational interventions, we need to pay attention to the dancers, the music and the reasons why people dance. After Latour (2005)

In output eight, the METHODS project findings were re-analysed using ANT, and by setting out certain already visited actors, comments and concepts. Indeed, the current retrospective analysis originated in output eight's retrospective of output seven, by considering the idea of actant switching in more detail and how ANT can recruit actors across distance via immutable mobiles. It develops a shift in thinking about project scope from drawing boundaries around actors to defining boundaries through connected actors in a network acting to solve a defined issue. Output eight's re-tracing of the actors in the educational map of output seven is a pivotal point in applying ANT to the mapping (after Deleuze & Guttari 1987) of the retrospective as a whole. Importantly, it adds the notion of ANT pivoting from a toolkit of analysis to one of design drawn together in the conclusions and proposed agile scaffold of a learning design. As such, output eight reconsiders certain positions on: technology; participatory practice; actants/mechanisms as mediators of agency in others; self-organisation; and, the evaluation of outcomes using the capability approach.

The importance of mediators in a network

Output eight considers the 'mediating' nature of actors: Latour (2005) notes that 'No matter how apparently simple a mediator may look, it may become complex; it may lead in multiple directions which will modify all the contradictory accounts attributed to its role' (Latour 2005, p.39). One key aspect of PBL's adaptability and fluidity is its simplicity and definition as a scaffold rather than a framework. The difference is distinguished by Pendleton-Jullian and Brown (2018 p.272): 'A framework is a complete structure, usually permanent, and gives form to that which it supports or

encloses or solves. A scaffold, on the other hand, is a temporary structure for supporting something until that something is able to stand on its own' (Output 8, p.2). In ANT, PBL as a pedagogy is an assembly of various actors that unites as a network to provide stability, but such stabilities are always threatened since, 'the bits and pieces assembled pro tem into an order are constantly liable to break down or make off on their own' (Law 1992, p.6). The form and nature of mediation is important within output eight, and PBL is lauded for its potential application across educational contexts, 'In its simplest form it is a problem-solving technique such as advocated by Polya (1957) and yet its focus can range from academically situated issues to complex problems that do not have a single correct answer —often (based on) real-life problems' (Output 8, p.2).

Although PBL is conceptualised as a black box in output eight, its fluidity is likened to a Lego set that a learning designer could use to build their own contextualised version. When considering actants/mechanisms in learning design, there are two main points: whether they release agency in learners, and can they be used or reformed by educators to fit their needs. In reality, unlike Scrum, which comes pre-packaged and defined, PBL is not a 'flat pack' but a set of ideas and activities that anyone can implement. As such, it is 'sticky' (Gladwell 2015) as a method that allows modification and a virus that adapts to its operating system (Laloux 2014). This is not to background or treat differently other actors in the transformation, the administrators who accommodated the changes required to assessment and curriculum, or the modifiers (individuals) of the METHODs project that introduced PBL and; the Aalborg trainers who propagated their open method. These were all instrumental in the 'translation' of PBL into the Palestinian HE context.

Output eight looked in detail at the PBL effect regarding curricula, pedagogy and assessment. This connection of three elements created the realisation that action taken on one part of the educational project, may also affect others. In this regard, output eight noted the entry of authentic contextual problems into curricula and the combined creation of educational spaces with explicit knowledge, leading to an increased range of assessment accommodated by the universities (output 8 p.3).

Figure 24 represents how curriculum is transmitted through a particular pedagogic approach towards a specified assessment. As there should be in an academy, there is leeway for expression in pedagogic style but often there is a 'stable state' maintained by standardisation of the three elements. In ANT, these elements would be described as intermediaries, where describing its inputs is enough to realise its outputs, and where an intermediary is an element of transmission of force or meaning (Latour 2005).

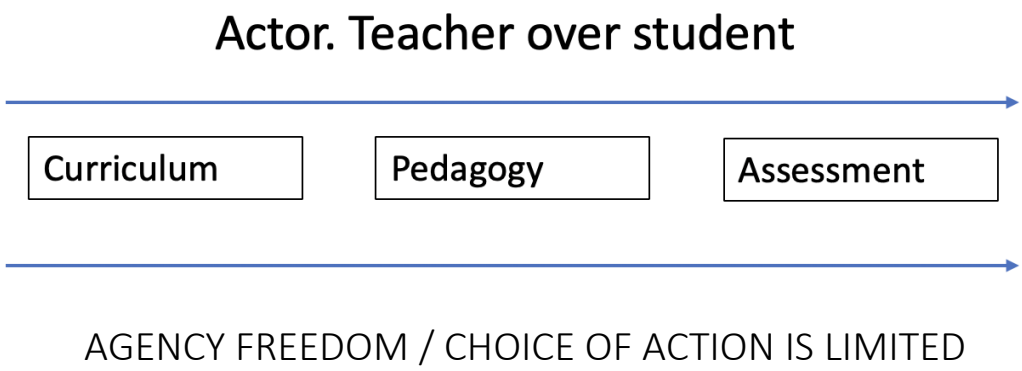

Figure 24. What is to be learned is aligned with how it is taught and assessed in a process where the output is defined by the inputs

In Figure 25, the inclusion of PBL gives more choice of curriculum content in the form of authentic issues, and a variety in assessment. Of course, there are many variations of PBL (Savin-Baden 2014), with different amounts of choice and control ceded to students. However, the PBL scaffold combines with the human actors to afford that choice.

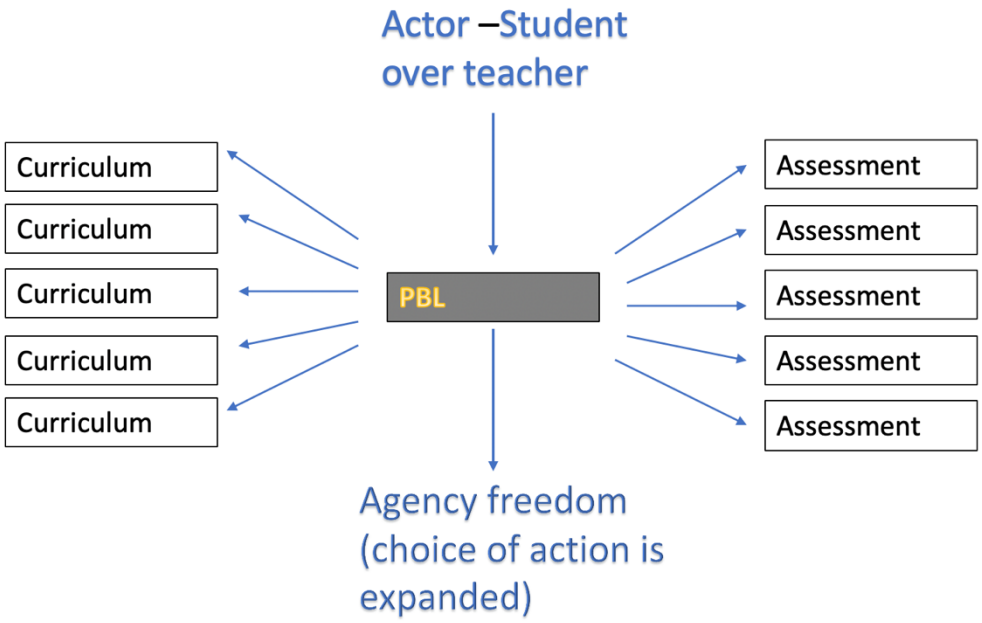

Figure 25. PBL acts as a mediator, increasing agency freedom

PBL as a self-generating actor network

Output eight introduced the notion that PBL works because curriculum topic/content and the context in which the problem is framed is supplied by the students, and subject knowledge is then recruited and applied to the problem. PBL invites participants to engage with issues in their context by researching and adding content and plans for action, concurrent with Suchman's (1985) notion of planning from situated action. Output eight also looks at PBL in relation to SO and notes that PBL provides a template in which to establish agentic SO. PBL is placed against Brandt's

(2016) triangle of SO and provides guiding principles, a goal (finding a solution) and motivation both through the extrinsic formal assessment but also intrinsically because the problem/goal is chosen by students. This is presented as a modified SO model.

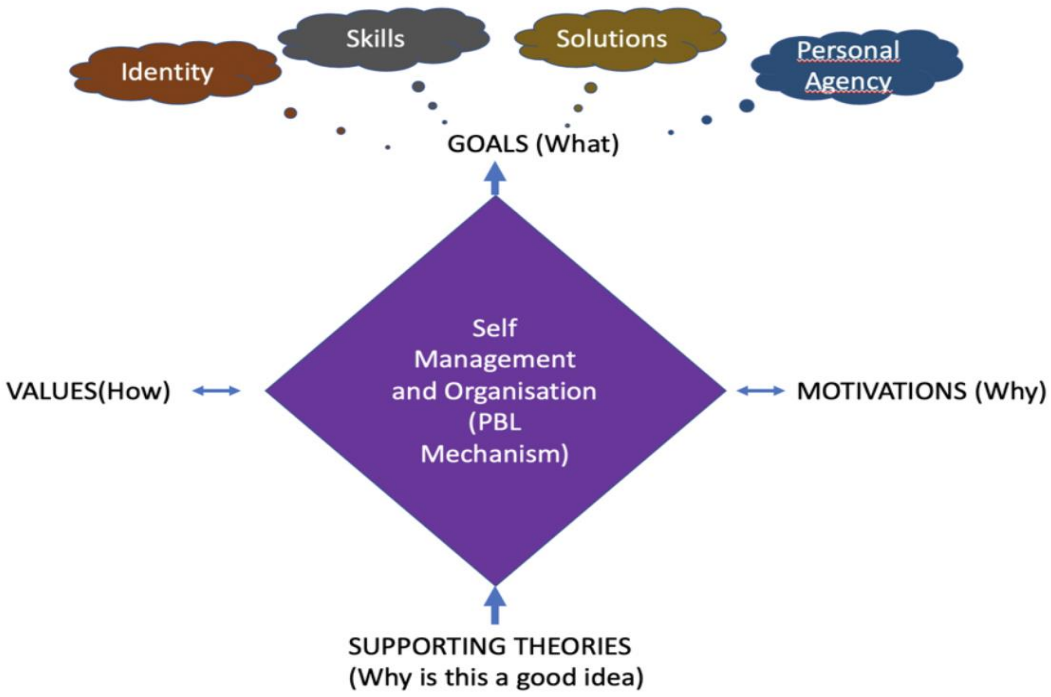

Figure 26. Components and outputs of SO created by PBL (Output 8)

PBL becomes a self-generating AN because the mechanism recruits other actors/actants into SO. Further, PBL is endorsed in education by supporting theories and is free and inexpensive to implement. Overall, the PBL technique as an actant in a network is defined and made visible —PBL is an agent of SO —meaning the components (actants) and products of SO should be present in any evaluation of PBL. In particular, what changes are evident in other actors within the network as a result of PBL's work as a mediator? Here, the concept of value/impact can be added, and the CA used to determine what that value might be.

Granularity of goal or purpose

Granularity (level of detail and the network's extent) is important in ANT as all actors have their ontologies —black boxes with networks making them up. This could be extrapolated to individuals in Palestine who may have the constraints of occupation inside them, but also, where they have these constraints, they may have the capacity for resistance. This may be a reason for their ready adoption of PBL, as it allowed them to articulate agency and act autonomously within areas over which they could have some control. A key point is that the working level of granularity within any AN is defined by the aim of the intervention and its purpose. For example, the goal of an education initiative might be to make education more inclusive and actors might be recruited to that goal by their individual objectives; equally, at another level the pedagogic method may generate its own goals and actions. It is only by looking at the network and the affordances of the technologies and nature of actants within it that an intervention may be assembled towards an overarching goal.

Network Boundaries

Output eight also considers how studies are bounded using ANT. Although I did not recognise it in output eight, it was here that I started to recognise the idea of assemblage of the social, Law's discussion of how researchers decide what is significant, and concepts such as absent presence, made present by absence, made manifestly present, and othering (Law, 2003). All the outputs recognise the larger 'social actors' outside of the immediate actors within an identified network. Sometimes these are given too much credence and stifle or prevent activity, or conversely create an urge to redress their influence and power, or make a decision to act anyway within their confines (Palestinian occupation). According to ANT, the

idea that nothing can change because it is too difficult or complex, or because we lack power, or social factors are against us (deprivation in output 6, for example) is a fallacy of our own making. Law (1992) notes that a core assumption of ANT is ‘the mechanics of power’. For example, ‘How it is that we never saw before that the Gorbachevs of this world really had feet of clay all along?’ (Law 1992, p.6)

An ANT analysis shows us how to bound the system under study through its actors, those that enter accounts and the issue is always where to cut that network. ANT networks are continually being made, remade and contested; they are sites of struggle for control, power and effect, and, in essence, dynamic systems. In output eight, I was just beginning with ANT and was still looking at components, and so the first diagram (Fig. 27) sets out the main boundaries of the education system and certain actors.

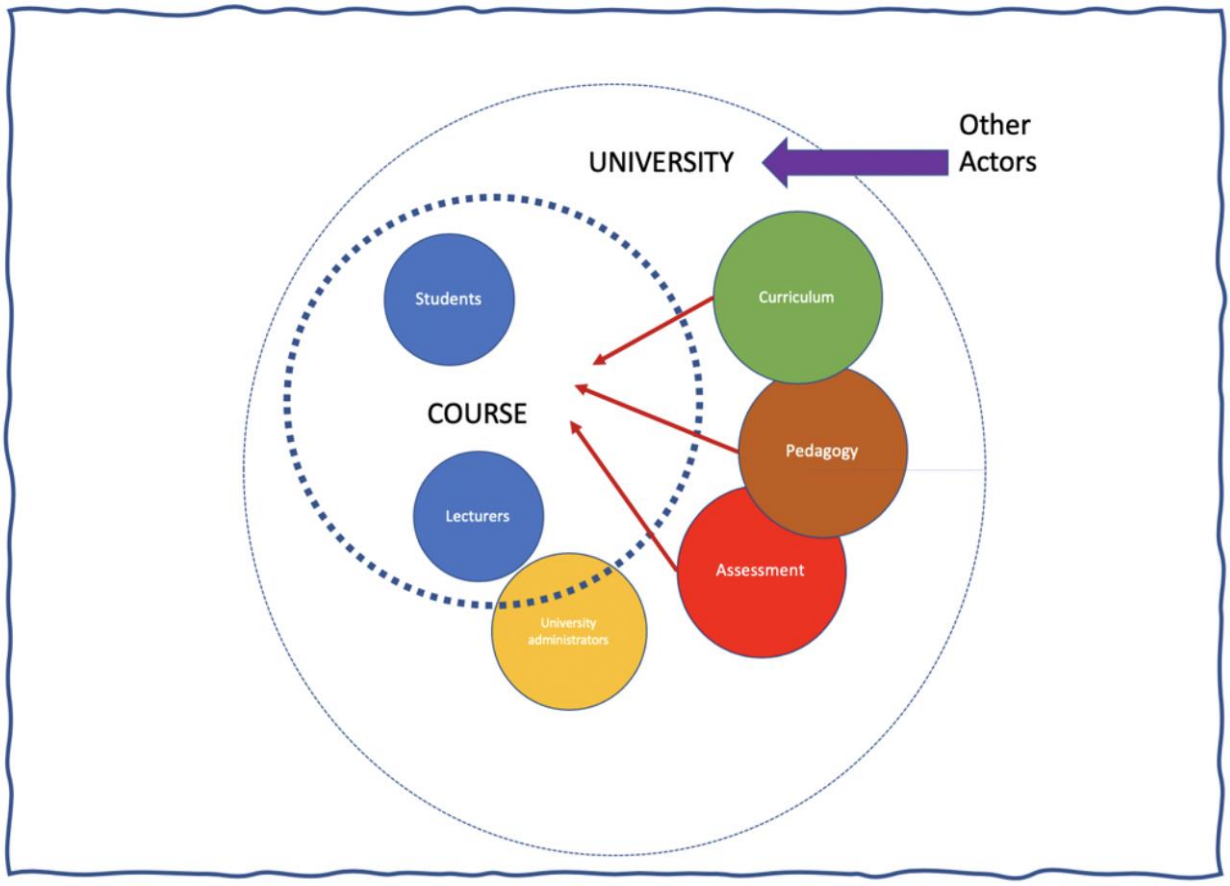

Figure 27. Initial diagram of the actors and boundaries in the METHODS project

Figure 27 shows the boundaries of the various systems and where the actors are. It notes that some actors may set constraints on activity, influencing the other actors within the system. At this point, I was drawing large boundaries around entities rather than defining the network through its actors. My second diagram after applying ANT (Fig. 28) is noticeably different.

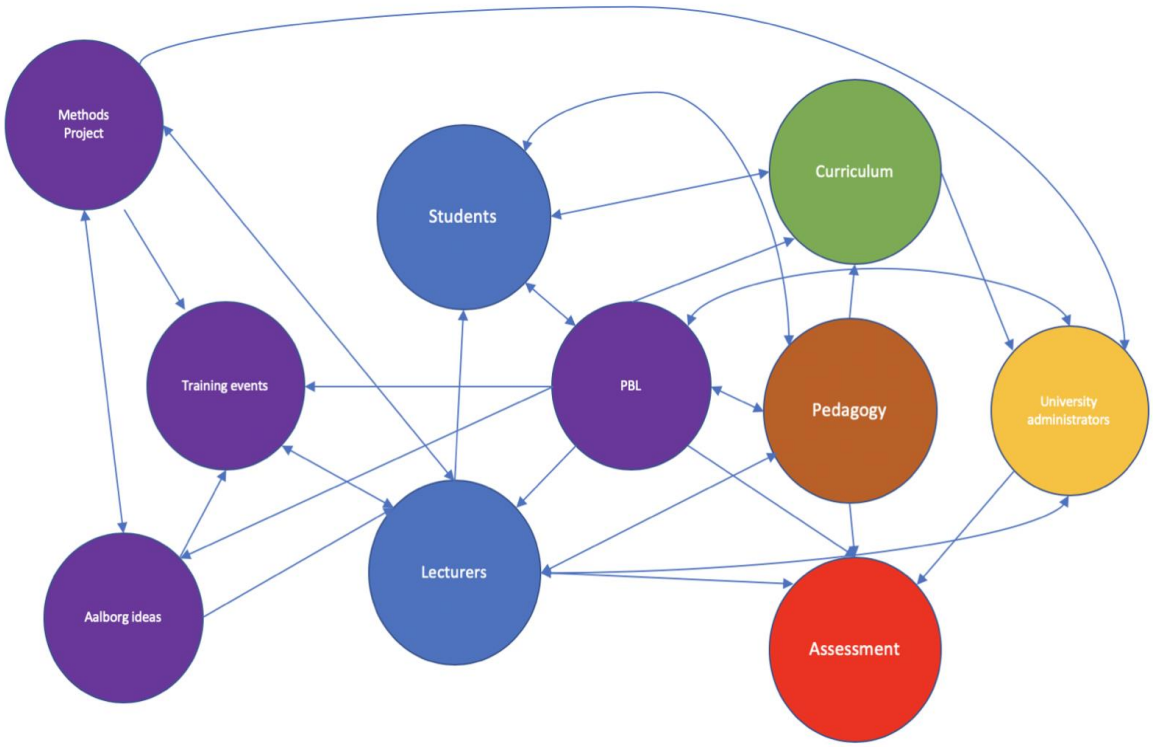

Figure 28. An actor network after the introduction of new actors (purple) from the METHODS project

Unlike Figure 27, Figure 28 shows how the actors interact and that the network is not about physical spaces —physical space and influence is collapsed. In output eight, I started to understand Latour's (2005) notion of actant and the agency released through actant interaction, causing transformation among others or the context. His notion of immutable mobiles (Latour 2005, p.237) as forms that travel between actors/actants can be related to the training manuals and models that were moved around in the METHODS project. I also began differentiating between mediator and intermediary and how this might be equated with actant switching in terms of what might be switched in and out within an educational system to effect change. I also

started to see curriculum, assessment and pedagogy as black boxes to examine, as they were often taken for granted, beyond reform and ‘acting as one’ (Latour 2005).

Alternative purposes for education

Another aspect of output 8 was the themes chosen by the students for their studies with the PBL actant. Several topics aligned with the notion of a regenerative economy (Fullerton 2015). For example, ‘some computer engineering students in Birzeit decide to create power supplies for local schools from old university computers, whereas students in Hebron tried to recycle stone waste into soil fertilizer’ (Output 8, p.10). This was reminiscent of the TPS, founded on the notion of scarce resources after World War 2, and yet these activities are not about growth or productivity but improving the economy and life of the Palestinian community. The students explored authentic, complex issues using a sort of speculative design (Dunne & Raby 2013), creating ‘what if’ hypotheses for change. In so doing, personal and collective agency was released by PBL through SO (Savin-Baden 2014), and students developed solutions to emerging problems through co-construction of meaning, convergent and divergent discussions, listening and negotiation (Bossche et al. 2006).

Seeing things differently

Although the four Palestinian institutions are geographically close, travel restrictions such as checkpoints can result in very localised university populations. As noted, I had not expected to find what I did so consistently across the four sites, and to me the acceptance of PBL seemed quite remarkable, despite similar results being found elsewhere. Indeed, there seemed to be something in particular about Palestine that made PBL a good fit. In this regard, the METHODS project could be seen as actant

switching, where didactic methods (a socio-intellectual technology) were replaced with another socio-intellectual technology. Both techniques were non-human actors but with different affordances, and PBL arguably replaced Latour's notion of intermediary with a mediator that effected change across the university systems. Using ANT retrospectively to bound and then explore the actants in a network gave me new insight into how such interventions can be evaluated (Output 8, p.16).

I also started to think about socio-technical engineering (Law 1988) in education, or creating something new by selecting and reshaping existing materials, in line with Pendleton-Jullian and Brown (2018):

> Designing changes to internal components of a network is often part of the work one takes on. By connecting or changing the degree of connectivity of one or more nodes, adding or removing nodes [...] one can alter the agency of individual components, clusters of components or even the entire network, by changing how content travels through the network (p.284).

Output 8 made me consider applying an ANT analysis to the other outputs as the foundation of this retrospective, and this led to further insights about how education is constructed and enacted in different contexts, and how certain themes emerge and are consolidated in the outputs. The next sections outline conclusions from the retrospective and then develop the use of ANT into a scaffold for transformational learning design, combining notions of APD, ANT and the CA.

Conclusions

This concluding section summarises the key findings and explains the outcomes that contribute to the development of the Agile scaffold for practitioners. It is important here to consider an education system's discernible purpose(s). Williams (1965) described three competing aspects of an education system: the production of a labour force which serves the needs of industry, the transmission of a culture (usually traditional and hierarchical), and the enabling of individuals to develop to their full capacities. At times, I have served each of these aspects and yet I am drawn to the latter, and this retrospective has allowed me perhaps to discover a way of prioritising this aim. At a higher level of granularity, there are issues around what type of production system is sustainable and whether the 'needs of industry' can be realigned from the treadmill of production (Gould et al 2008) and endless increases in consumption and waste, to a cyclical economy (Fullerton 2015). Again, I believe the latter should be supported by the education system (transmission of culture) and there are examples of this happening, notably in Finland (Sitra 2019).

Generally, APD and the TPS (output 5) is predicated on maximising value and minimising waste and yet it remains a method for increasing productivity and serving economic growth, unless appropriated for the needs of a cyclical economy. For a while, I thought Scrum might be ideally suited to education as a way of opening space for learner and teacher agency within a high risk, control-based environment. Perhaps it is, as evidenced by the growing 'eduscrum' movement, but it threatens to become just another orthodoxy due to its roles, ceremonies and rules, despite its potential. It is important, however, alongside any proposed 'method', to consider both impact and value in education. This is why the CA (outputs 5–6) should be a component of any educational project, in order to judge its effects.

One approach to the CA (Nussbaum 1995, in particular) specifies what a rights-based entitlement might be in terms of lists of capabilities (Burchardt & Vizard, 2009), while another (Sen 1992) rests on defining capabilities from people's contexts. As Robeyns (2003, p.64) explains, Sen 'does not stipulate which capabilities should be taken into account, or how different capabilities should be aggregated in an overall assessment. Applying the capability approach implies that we choose the relevant capabilities and indicate how important each will be in an overall judgment.' Equally, although the capability approach focuses on the beings and doings of individuals, it recognises that this does not occur in isolation and that other contextual factors can constrain. Therefore, the CA can be aligned with ANT as it enables the interrogation of constraints on capability. In education, this interrogation could expand across types of schools to exam system equity, and the intersectionality of class, gender and deprivation, to address certain issues that arise within Williams' three purposes. Capability should be an actor by which an intervention can be judged in terms of what it enables people to do and be, and also to assess the degree of 'AF' that individuals and groups choose to develop into valued functioning. ANT allows interrogation of the assembled context and how other actors act to produce or hinder the realisation of capability through agency, realised through the network's interaction. ANT's what and how and CA's do and be are aligned.

At a lower level of granularity, an ANT analysis allows a wider and more reflexive system view of those trying to effect change (Output 6). The heterogeneity of the actors, leading to symmetrical analysis of actor networks, gave me a new perspective beyond the binary oppositions in my earlier outputs. Output eight's analysis of output seven sent me on this retrospective path, from which I could

narrate what happened and form a different view. In reviewing the outputs, I saw an evolving view which I believe reflects Deleuze and Guttari's (1987) notions of mapping and tracing —the rhizome versus the arboreal system, where the tree with its roots and branches is a tracing whereas the map is the landscape formed by interconnecting points. Mapping is about seeing what is there and how it might be produced and configured, but tracing captures, structures and ties things down from a map. In the retrospective, both of these occur, as it revisits the landscape of the outputs, realises that there are expanding multiplicities of actors, and traces structures from the maps (Deleuze & Guttari 1987, p.42). Rather than the retrospective being the definitive interpretation, it is a map which could be differently drawn depending upon position and context. My position in the earlier outputs eschews mapping entirely by selecting certain points, and expects to encounter cause and effect by tracing the paths from point to point; I accepted the neoliberal education models that I encountered. In later outputs, I recognised a more fluid system enabled by the ever expanding ontologies and assemblages of ANT. Actors converge through self-organisation, and the complexities of how this happens can be mapped. This use of ANT means I do not always see things as I did at the time, and although I act back and judge my early endeavours harshly, I feel it is good to reflect and re-examine. The concentration on the how and the what of who acts, seen more clearly in retrospect, in order to trace a network from a wider map, gave insights not only into how the scope of interventions may be defined but also the importance of recognising what was omitted as much as included (outputs 1–4). I find it extremely insightful to consider types of presence and absence, the notion of othering (Law op cit.) and how things are made 'manifest' within a context, as well as how that context is defined. This is especially so of how certain phenomena can 'disappear' and

others become powerfully present but remain unexplained. I now see this happening daily in my current work and I question how assumptions are made about inclusion and exclusion. Further, the inclusion of researchers such as myself as actors (a key realisation for my reflexive self), whilst a well-rehearsed argument in other fields such as anthropology (Strathern 1996), was made manifest to me through the retrospective. I acted and so within that action I saw retrospectively that I made choices and assembled networks towards particular ends (Latour 2005). The key point here is that researchers are also actors that enter accounts and that those accounts should not be privileged any more than other actors in a network (Fenwick & Edwards 2012).

Equally, the notion that every actor in a network is constituted from its own network ontology was a moment of insight, and the concepts of punctualisation and 'black boxing' showed how certain actors were used to add weight to arguments or act without being interrogated further (outputs 3–4, 6). For example, I have often wondered when colleagues have said things like, 'you can't do that the curriculum won't allow it' —where indeed did the 'curriculum' get such power? It is that idea of looking at a network to see where the power lies, of who speaks in the name of whom and how that is manifest. What I also like about ANT is its empiricism —where an ANT analysis requires the detail — 'both god and the devil is in the detail, so show me the detail' (Latour 2005, p.137). As such, I believe it is an ideal approach to construct small-scale learning design activities, to interrogate situated practices and improve them at the class, course, subject, school or area level, in terms of a larger project (output 8). 'One of the core assumptions of actor-network theory (is) that

Napoleons are no different in kind to small-time hustlers, and IBMs to whelk stalls' (Law 1992, p.380). The latter point disregards perceptions of 'things beyond our control'. For example, the occupation of Palestine is a real and present influence on education, but this should not stop the transformation of a practice that could ultimately act against it.

One of the most powerful aspects of ANT, mirrored in Scrum (output 5) and PBL (output 7), is its ability to energise actors towards a central purpose through translation, and particularly its first stage of problematisation. SO is similar to ANT but more granular and I have wondered whether pedagogic mechanisms that use SO, ceding control to the participants and giving them greater agency, are just small versions of ANs. Thomas (2008 p.164) notes that 'discussions provoked by problematisation, are also shifts in power relations; confrontation with the problem requires restructuring some power relations to adapt to or solve the problem'. Agency is central to the discussion (and the CA) but not as an individual or even collective human agency. It is more about what combinations of heterogenous actors combine to release AF and open space for change and the production of new configurations of action and human capability. ANT allows researchers to seek marginalised voices, the whelk stall as much as the IBMs, and their potential to act. Added to this, ANT describes its networks, as constantly forming, breaking down, contracting and expanding, like Deleuze and Guttari's (1987) smooth and striated spaces. ANT adds purpose for formation and networks take shape and are mapped by those that contribute towards the purpose or act against it. ANT attempts to capture system dynamism and show how stable states might be disrupted.

This leads me to the distinction in ANT between mediators and intermediaries (which deliver messages as they are) (output 8); whilst both are necessary within a network and can change function, it appears that mediators are more likely to lead to transformation and different outcomes and possibly ‘shifts in power relations’ when present in a network. As Pendleton-Jullian and Brown (2018) note, this exchange of actors (mechanisms) is part of the work taken on to make changes in design, which also involves by necessity choices about othering and exclusion. It is this dynamism that is also attractive to Foley and Lockton (2018) and their idea of actant switching and speculative design. The latter allows inclusion of other actors using a series of ‘what if?’ scenarios in particular contexts, to project change rather than actually implement it. It is this layer of granularity that intrigues me the most for developing learning designs and interventions (output 8) because it is possibly easiest to see the effects by holding other actors constant and changing one thing. To incorporate some of these ideas so that they might contribute to educational change in conclusion to the retrospective,

I have developed a prospective outline for an Agile scaffold for learning design. This combines the CA, elements of the Scrum Agile framework, and ANT in a design framework to create educational interventions, . These are complementary because all three are based on notions of agency: AF in the CA, the agency of the actors in a network in ANT, and SO within Scrum. Additionally, they are focused on situated practice and empiricism and so are context-based. To use ANT as a means for heterogenous socio-technical engineering in education, having the CA as an appraising actor of AF (expanded or constrained) requires an implementation framework (IF) that is part of the design but also acts. Scrum supplies this IF through its focus on inspection and the adaption of the process of the AN creation by its

participants. This is achieved through ceremonies (reviews and retrospectives), the philosophy of incremental and iterative design, and commitment to transparency. I am conscious here that ANT is not supposed to be a method (Latour 2009) and yet a purposeful ANT approach can create new possibilities through problematisation. Scrum product development is an actor in the development of solutions, and the CA addresses whether things might change. The combination is complementary.

Towards an Agile scaffold for ANT-based learning design

This section connects ANT and Agile and presents six principles (Fig.27) that can be applied at different levels of granularity to reform or transform practice through a process of iterative design. The process can be adopted by teachers in class, researchers, and curriculum designers. It is intended to be adapted to context, with each implementation being different as a result. The starting point for APD is the product vision or purpose, as a response to a customer's need or problem, and is thus similar to the problematisation stage in the translation process in ANT. This means that Agile aligns with ANT with regard to responding to problems or problematisation. Crucial within an Agile ethos is the idea of responding to change rather than following a plan (which is about inspecting and adapting the process/product as it develops), and if customer requirements for the product change then the components can also. Responding to change is the 'how and what' of situated action (Suchman 1985) and it is this acting purposefully within a context that is central to releasing self-organisation and developing capabilities. The crucial aspect is to decide on what value or impact you want your product to realise and what problem it addresses. Not all solutions are equal in terms of realising a purpose and they may sometimes have an opposite negative effect.

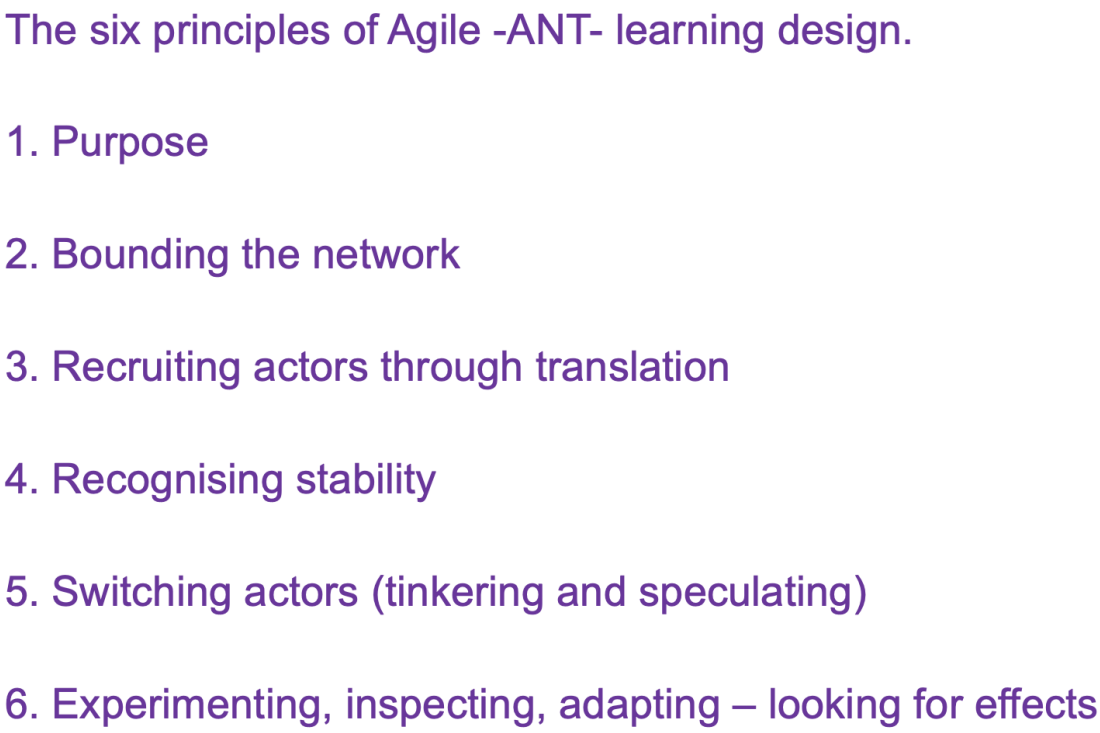

Figure 27. The six principles of the Agile-ANT learning design scaffold

This aspect of Agile gives rise to the first principle of the scaffold: purpose. None of the outputs overtly specified a purpose for their networks, although these were discovered through the retrospective analysis. Defining purpose may also lead to decisions about what is included/excluded and so it is important to heed this and see who/what might act. However, it is also key when using ANT as a design process that a purpose for problematisation and what you want to achieve is specified —this is how networks arise and maps of actors are created. The problem being addressed and what speculative value the project should realise is central to the design, with the proviso that this may change or produce unintended impacts as the intended modification moves into the network. This might be something as simple as 'Learners negotiate what and how they study' or a list of specific attributes, such as

‘As a learner, I want to develop my research skills so that I can find out more about air pollution in my neighbourhood’. At another level, it might be possible to align any activity with ideas of a regenerative economy, and develop curricula based on this. Equally, the purpose may be more policy-oriented, such as introducing a new assessment system.

The second principle focuses on the scope of the activity and bounding the network of potential human and non-human actors assembled to enact the change and address the problem. Issues of who speaks for whom and who is heard (output 4) and what is excluded/included (output 3) are also part of this process. The bounding of a network by who/what acts, and realising it may expand or contract (Deleuze & Guttari 1987) is as important as thinking about the different goals each actor has (output 2). Taking a wider view of actors outside the immediate domain is advisable to ensure that the most effective elements are included; for example, in output 6 a focus on community actors may have been more beneficial than on schools, or, indeed, a focus on the border between the two. Essentially, mapping all the actors is more important than tracing the prominent ones. This map is then cut (defined by all who act and enter accounts) towards a purpose but retains open borders so that others may be recruited or enter. As Law (2003) notes, borders must be acknowledged and decisions taken about where to draw them and about how they are policed because this decides what is manifest (present) and what is not (othered).

The third principle involves actors being carefully recruited to a purpose through the translation stages, and it is important to prepare contingencies to counter actors who might act back (outputs 1–2).

The fourth principle concerns the status of the actors crucial to the network's functioning —the intermediaries —who stabilise it so that other elements may be modified (output 3–4).

The fifth principle centres on which network actors may be switched and where replacing an intermediary with a mediator might be beneficial. It is important to consider how fluid (output 2) the mediator is and how adaptive to other actors (outputs 7–8). In education, the creation of an AN can focus initially on curricula, pedagogy, assessment and/or knowledge creation (outputs 1–2, 7 presenting, publishing and making). Also, how far the change in one element affects change in others needs to be considered (outputs 5–7), as do the resulting effects on the context and the extent of the network. In each case, it is important to consider in advance how the new element might contribute to the network developing AF, capability and functioning, for its corresponding actors (outputs 5–6). This should be done by speculating with as many different forms of new actor as possible to model what might happen and plan accordingly. Which capabilities can be converted to valued functioning, and what limiting actors might be present to prevent their conversion, are questions which also need to be considered. The way a network configures itself to convert capabilities into functioning is another question for consideration during the design and the process of implementation.

In the sixth principle, agile sprints can be used to run time-boxed experiments of actant switching (output 5) by introducing minimum viable changes into the network and seeing what happens. Changes do not need to be disruptive or create discord, but can persuade or even fail. How far and what effects particular actors have on other actors should also be observed, especially adverse effects. Such observation

requires the introduction of evaluative mechanisms of the effects of the change. At this point, the reflexivity of researchers is needed as these evaluative elements are also actors and may produce other effects. It is important to overtly inspect and adapt the intervention by using the idea of sprint reviews of impacts and retrospectives on the process of implementation (output 5). Hopefully, this will allow suitable reflective and reflexive practice to develop so that conclusions and future actions in practice can be developed and implemented. At all times the position of the instigator in the network must be recognised to understand any influence or bias that is being placed on outcomes, for whatever reason, to maintain a symmetrical approach.

Finally, to reiterate, whilst reflexivity of outlook and approach is crucial to any change, one must also act but be aware of the multiple possibilities that may result from action and interaction with others, and how this action is also part of the agency of the network. The principles outlined above define a scaffold for mapping the territory of education and creating dynamic assemblages of the social that might be oriented towards developing capabilities. They also challenge the educator to be aware of both ‘good’ and ‘bad’ effects and to understand their own position in the network creation and choices that are made. Ultimately, however, this is a contribution towards practicality and a method to enact change based on empirical process control (who/what acts). Although short-term, time-bound, funded research projects demand a particular trajectory towards completion, it is perhaps incumbent upon researchers to iteratively inspect and adapt the process and their active roles in it as part of the design. The contribution to knowledge here is the realisation that educators can act back within their contexts through a process of: mapping the actors; designing heterogenous socio technical engineering experiments (e.g. actant

switching); and, observing what happens. By using the principles of the scaffold, educators may realise that networks are precarious and never far from power relations. Using ANT helps to examine these relationships and how they are made manifest by looking at their detail, whilst reminding those involved to be self-aware of their place within them on various levels. Educators will have a wider system view of human (including their position) and non-human actors, materials, methods, policies and technologies, and see how they can be constituted towards a purpose. As Law (1992, p.8) says, 'Our task is to study these materials and methods, to understand how they realise themselves, and to note that it could and often should be otherwise'. Hopefully, educators may not only realise that once an AN-designed learning environment is established it may need continuous attention, adjustment and maintenance, but also that it may fail or transform into something different. This may be difficult to do in practice and demands a plan or at least a shape, but there are elements in speculative design and Agile that allow experimentation to be the 'plan' per se. 'What distinguishes the map from the tracing is that it is entirely oriented toward an experimentation in contact with the real.' (Deleuze and Guttari 1987, p.41). As such, this set of principles is a tracing and a mapping which is hopefully fluid enough to be an actor in and of itself that moves and joins other networks and is realised as such.

The concluding proposition of this thesis is that ANT, Agility, and self-organisation, combined with a reflexive position, can facilitate change in educational systems to release AF and develop capabilities. An actor network can be engineered to work and develop a learning environment that recognises both freedoms and constraints, if combined with a purpose that is closer to the emancipatory than the transmissive.

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